

AO 120 (Rev. 08/10)

TO: Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450	REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK
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In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Western District of Texas - Waco Division on the following

☐ Trademarks or ☒ Patents. (☐ the patent action involves 35 U.S.C. § 292.);

DOCKET NO. 6:22-cv-575	DATE FILED 6/3/2022	U.S. DISTRICT COURT Western District of Texas - Waco Division
PLAINTIFF EIGHT KHZ, LLC		DEFENDANT META PLATFORMS, INC.; META PLATFORMS TECHNOLOGIES, LLC
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1 9,282,196	3/8/2016	Glen A. Norris; Philip Scott Lyren
2 9,674,628	6/6/2017	Glen A. Norris; Philip Scott Lyren
3 10,448,184	10/15/2019	Philip Scott Lyren; Glen A. Norris
4 10,917,737	2/9/2021	Philip Scott Lyren; Glen A. Norris
5 9,226,090	12/29/2015	Glen A. Norris; Philip Scott Lyren

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1		
2		
3		
4		
5		

In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE
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Copy 1—Upon initiation of action, mail this copy to Director Copy 3—Upon termination of action, mail this copy to Director
Copy 2—Upon filing document adding patent(s), mail this copy to Director Copy 4—Case file copy

AO 120 (Rev. 08/10)

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PLAINTIFF EIGHT KHZ, LLC		DEFENDANT META PLATFORMS, INC.; META PLATFORMS TECHNOLOGIES, LLC
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1 10,368,179	7/30/2019	Philip Scott Lyren; Glen A. Norris
2 10,798,509	10/6/2020	Philip Scott Lyren; Glen A. Norris
3 11,172,316	11/9/2021	Philip Scott Lyren; Glen A. Norris
4 11,290,836	3/24/2020	Glen A. Norris; Philip Scott Lyren
5		

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
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 Copy 2—Upon filing document adding patent(s), mail this copy to Director Copy 4—Case file copy



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/062,633	11/09/2021	11172316	PSL-038 (CON 7)	2402

64021 7590 10/20/2021
PHILIP S. LYREN, PC
289 Woodland Avenue
Wadsworth, OH 44281

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b) (application filed on or after May 29, 2000)

The Patent Term Adjustment is 0 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (<http://pair.uspto.gov>).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Patents Stakeholder Experience (OPSE), Stakeholder Support Division (SSD) at (571)-272-4200.

INVENTOR(s) (Please see PAIR WEB site <http://pair.uspto.gov> for additional inventors):

Philip Scott Lyren, Bangkok, THAILAND;
Glen A. Norris, Tokyo, JAPAN;

APPLICANT(s) (Please see PAIR WEB site <http://pair.uspto.gov> for additional applicants):

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The USA offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to encourage and facilitate business investment. To learn more about why the USA is the best country in the world to develop technology, manufacture products, and grow your business, visit SelectUSA.gov.

IR103 (Rev. 10/09)



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY. DOCKET NO.	TOT CLAIMS	IND CLAIMS
17/062,633	10/05/2020	2651	830	PSL-038 (CON 7)	20	3

CONFIRMATION NO. 2402
CORRECTED FILING RECEIPT



0000000128933501

64021
PHILIP S. LYREN, PC
289 Woodland Avenue
Wadsworth, OH 44281

Date Mailed: 10/07/2021

Receipt is acknowledged of this non-provisional utility patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF FIRST INVENTOR, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection.

Please verify the accuracy of the data presented on this receipt. If an error is noted on this Filing Receipt, please submit a written request for a corrected Filing Receipt, including a properly marked-up ADS showing the changes with strike-through for deletions and underlining for additions. If you received a "Notice to File Missing Parts" or other Notice requiring a response for this application, please submit any request for correction to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections provided that the request is grantable.

Inventor(s)

Philip Scott Lyren, Bangkok, THAILAND;
Glen A. Norris, Tokyo, JAPAN;

Applicant(s)

Philip Scott Lyren, Bangkok, THAILAND;
Glen A. Norris, Tokyo, JAPAN;

Power of Attorney:

Philip Lyren--40709

Domestic Priority data as claimed by applicant

This application is a CON of 16/938,936 07/25/2020 PAT 10798509
which is a CON of 16/558,078 08/31/2019 PAT 10728682
which is a CON of 16/445,268 06/19/2019 PAT 10602291
which is a CON of 16/162,416 10/17/2018 PAT 10440489
which is a CON of 15/944,796 04/04/2018 PAT 10117038
which is a CON of 15/424,901 02/06/2017 PAT 9980072
which is a CON of 15/049,071 02/20/2016 PAT 9591427

Foreign Applications for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see <http://www.uspto.gov> for more information.) - None.

Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: No

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

If Required, Foreign Filing License Granted: 10/14/2020

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 17/062,633**

Projected Publication Date: Not Applicable

Non-Publication Request: No

Early Publication Request: No

**** SMALL ENTITY ****

Title

WEARABLE ELECTRONIC DEVICE DISPLAYS A 3D ZONE FROM WHERE BINAURAL SOUND EMANATES

Preliminary Class

381

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign

page 2 of 4

patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at <http://www.uspto.gov/web/offices/pac/doc/general/index.html>.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, <http://www.stopfakes.gov>. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

SelectUSA

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The U.S. offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to promote and facilitate business investment. SelectUSA provides information assistance to the international investor community; serves as an ombudsman for existing and potential investors; advocates on behalf of U.S. cities, states, and regions competing for global investment; and counsels U.S. economic development organizations on investment attraction best practices. To learn more about why the United States is the best country in the world to develop technology, manufacture products, deliver services, and grow your business, visit <http://www.SelectUSA.gov> or call +1-202-482-6800.



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

NOTICE OF ALLOWANCE AND FEE(S) DUE

64021 7590 10/01/2021
PHILIP S. LYREN, PC
289 Woodland Avenue
Wadsworth, OH 44281

EXAMINER

PATEL, YOGESHKUMAR G

ART UNIT

PAPER NUMBER

2651

DATE MAILED: 10/01/2021

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/062,633	10/05/2020	Philip Scott Lyren	PSL-038 (CON 7)	2402

TITLE OF INVENTION: Capturing Audio Impulse Responses of a Person with a Smartphone

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	\$600	\$0.00	\$0.00	\$600	01/03/2022

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 1/2 the amount of undiscounted fees, and micro entity fees are 1/2 the amount of small entity fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Maintenance fees are due in utility patents issuing on applications filed on or after Dec. 12, 1980. It is patentee's responsibility to ensure timely payment of maintenance fees when due. More information is available at www.uspto.gov/PatentMaintenanceFees.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via EFS-Web.

By mail, send to: Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

By fax, send to: (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

64021 7590 10/01/2021
PHILIP S. LYREN, PC
289 Woodland Avenue
Wadsworth, OH 44281

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being transmitted to the USPTO via EFS-Web or by facsimile to (571) 273-2885, on the date below.

(Typed or printed name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/062,633	10/05/2020	Philip Scott Lyren	PSL-038 (CON 7)	2402

TITLE OF INVENTION: Capturing Audio Impulse Responses of a Person with a Smartphone

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	\$600	\$0.00	\$0.00	\$600	01/03/2022

EXAMINER	ART UNIT	CLASS-SUBCLASS
PATEL, YOGESHKUMAR G	2651	381-001000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

- ☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
- ☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-09 or more recent) attached. Use of a Customer Number is required.

2. For printing on the patent front page, list

- (1) The names of up to 3 registered patent attorneys or agents OR, alternatively, 1 _____
- (2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed. 2 _____
- 3 _____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE

(B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ☐ Individual ☐ Corporation or other private group entity ☐ Government

4a. Fees submitted: ☐ Issue Fee ☐ Publication Fee (if required) ☐ Advance Order - # of Copies _____

4b. Method of Payment: (Please first reapply any previously paid fee shown above)

- ☐ Electronic Payment via EFS-Web ☐ Enclosed check ☐ Non-electronic payment by credit card (Attach form PTO-2038)
- ☐ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. _____

5. Change in Entity Status (from status indicated above)

- ☐ Applicant certifying micro entity status. See 37 CFR 1.29
- ☐ Applicant asserting small entity status. See 37 CFR 1.27
- ☐ Applicant changing to regular undiscounted fee status.

NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.

NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.

NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
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Alexandria, Virginia 22313-1450
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/062,633	10/05/2020	Philip Scott Lyren	PSL-038 (CON 7)	2402
EXAMINER				
PATEL, YOGESHKUMAR G				
ART UNIT			PAPER NUMBER	
2651				

DATE MAILED: 10/01/2021

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b) (Applications filed on or after May 29, 2000)

The Office has discontinued providing a Patent Term Adjustment (PTA) calculation with the Notice of Allowance.

Section 1(h)(2) of the AIA Technical Corrections Act amended 35 U.S.C. 154(b)(3)(B)(i) to eliminate the requirement that the Office provide a patent term adjustment determination with the notice of allowance. See Revisions to Patent Term Adjustment, 78 Fed. Reg. 19416, 19417 (Apr. 1, 2013). Therefore, the Office is no longer providing an initial patent term adjustment determination with the notice of allowance. The Office will continue to provide a patent term adjustment determination with the Issue Notification Letter that is mailed to applicant approximately three weeks prior to the issue date of the patent, and will include the patent term adjustment on the patent. Any request for reconsideration of the patent term adjustment determination (or reinstatement of patent term adjustment) should follow the process outlined in 37 CFR 1.705.

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 30 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. **DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.** Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b) (2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Notice of Allowability	Application No. 17/062,633	Applicant(s) Lyren et al.	
	Examiner YOGESHKUMAR G PATEL	Art Unit 2651	AIA (FITF) Status Yes

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to 10/18/2020.
☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

3. ☒ The allowed claim(s) is/are 21-40. As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to **PPHfeedback@uspto.gov**.

4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
Certified copies:
a) ☐ All b) ☐ Some* c) ☐ None of the:
1. ☐ Certified copies of the priority documents have been received.
2. ☐ Certified copies of the priority documents have been received in Application No. _____.
3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).
* Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☒ Notice of References Cited (PTO-892)	5. ☐ Examiner's Amendment/Comment
2. ☐ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____.	6. ☒ Examiner's Statement of Reasons for Allowance
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material _____.	7. ☐ Other _____.
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____.	

/YOGESHKUMAR PATEL/ Primary Examiner, Art Unit 2651	
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DETAILED ACTION

Notice of Pre-AIA or AIA Status

1. The present application, filed on or after March 16, 2013, is being examined under the first inventor to file provisions of the AIA.

2. A terminal disclaimer (TD) filed by an Applicant on 15 September 2021 to disclaim prior Patent #10,798,509 has been considered.

3. Claims ~~21-40~~ are allowed.

The closest prior art neither disclose nor sufficiently suggest the combination of features as claimed and arranged by applicant when read in light of the specification.

The closest prior art fails to teach a method comprising:

dividing, with a portable electronic device (PED) held in a hand of a user, an area around the user into a zone that extends around the user and that includes a sound localization point (SLP) from where binaural sound in empty space originates to the user;

playing, with speakers in a wearable electronic device (WED) worn on a head of the user, the binaural sound that originates from the SLP in empty space;

tracking, with one or more sensors in the WED worn on the head of the user, the PED to determine when the PED held in the hand of the user is moving outside the zone that extends around the user; and

displaying, with the WED worn on the head of the user, a virtual reality (VR) image that shows the zone in response to the WED determining that the PED is moving outside the zone.

These limitations, in combination with the remaining limitations of independent Claims 21, 29, and 37 are neither taught nor suggested by the prior art of record.

4. Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to YOGESHKUMAR G PATEL whose telephone number is (571)272-3957. The examiner can normally be reached on 7:30 AM-4 PM PST.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at <http://www.uspto.gov/interviewpractice>.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Duc Nguyen can be reached on 571-272-7503. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only.

For more information about the PAIR system, see <https://ppair-my.uspto.gov/pair/PrivatePair>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/YOGESHKUMAR PATEL/
Primary Examiner, Art Unit 2651

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*	B	US-20170045941-A1	02-2017	Tokubo; Todd	A63F13/53	1/1
*	C	US-20150296288-A1	10-2015	Anastas; Chris T.	H04R5/033	381/77
*	D	US-9464912-B1	10-2016	Smus; Boris	G06F3/165	1/1
*	E	US-20140003640-A1	01-2014	PURIA; Sunil	H04R1/265	381/318
*	F	US-20090097681-A1	04-2009	Puria; Sunil	H04R25/405	381/318
*	G	US-20160228771-A1	08-2016	Watson; Brian	A61B5/4023	1/1
*	H	US-20160195856-A1	07-2016	Spero; Yechezkal Evan	G06N5/046	700/90
*	I	US-20130041648-A1	02-2013	Osman; Steven	H04S7/304	704/2
*	J	US-20150245159-A1	08-2015	Osman; Steven	H04S7/304	381/303
*	K	US-8989417-B1	03-2015	Zhong; Xuan	H04R5/033	381/326
*	L	US-20100080396-A1	04-2010	Aoyagi; Hiromi	H04S1/005	381/17
*	M	US-20140079212-A1	03-2014	SAKO; YOICHIRO	H04M1/60	379/395

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Notice of References Cited

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*	B	US-20170289728-A1	10-2017	YAMASHITA; Kosei	G06F3/013	1/1
*	C	US-20170272889-A1	09-2017	ABE; Kazutaka	H04S7/303	1/1
*	D	US-20170171672-A1	06-2017	Recker; Karrie LaRae	H04S7/304	1/1
*	E	US-20170105083-A1	04-2017	Nair; Varun	H04S7/30	1/1
*	F	US-20170094440-A1	03-2017	BROWN; C. Phillip	H04S7/30	1/1
*	G	US-20170078820-A1	03-2017	BRANDENBURG; Karlheinz	H04S7/301	1/1
*	H	US-20150124975-A1	05-2015	PONTOPPIDAN; Niels Henrik	G06F3/162	381/23.1
*	I	US-20160269849-A1	09-2016	Riggs; Jason	H04S7/301	1/1
*	J	US-20160249151-A1	08-2016	Grosche; Peter	H04S3/002	1/1
*	K	US-20160247518-A1	08-2016	Schuller; Bjoern	H04S7/30	1/1
*	L	US-20160104491-A1	04-2016	LEE; Taegyu	H04S3/008	381/22
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*	B	US-20130036452-A1	02-2013	Yamashita; Kosei	H04S5/00	726/3
*	C	US-20150326963-A1	11-2015	SORENSEN; Peter Schou	H04R1/1041	381/74
*	D	US-20150304790-A1	10-2015	YAMASHITA; Kosei	G06F3/167	381/303
*	E	US-20150271620-A1	09-2015	Lando; Joshua Brandon	H04S5/005	381/18
*	F	US-20150223002-A1	08-2015	Mehta; Sripal S.	H04S7/30	381/303
*	G	US-20150208190-A1	07-2015	Hooks; Spencer S.	H04S7/301	381/303
*	H	US-20150092965-A1	04-2015	Umminger; Frederick	H04S7/304	381/310
*	I	US-20120078398-A1	03-2012	Xu; Dezheng	G10H7/02	700/94
*	J	US-20150030159-A1	01-2015	OZCAN; Koray	G06F3/165	381/17
*	K	US-20140355796-A1	12-2014	Xiang; Pei	G10L19/008	381/303
*	L	US-20140350944-A1	11-2014	Jot; Jean-Marc	G10L19/008	704/500
*	M	US-20140334626-A1	11-2014	LEE; Yoon-jae	H04S5/00	381/17

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*	B	US-20140114560-A1	04-2014	JENSEN; Jakob	H04S7/304	701/409
*	C	US-20130343550-A1	12-2013	ARAKI; Junji	H04S5/00	381/17
*	D	US-20130294605-A1	11-2013	HAGIOKA; Ryuichi	H04S5/00	381/17
*	E	US-20130208899-A1	08-2013	Vincent; Jon	A63F13/428	381/17
*	F	US-20130208926-A1	08-2013	Vincent; Jon	A63F13/42	381/300
*	G	US-20130208900-A1	08-2013	Vincent; Jon	A63F13/54	381/17
*	H	US-20130208898-A1	08-2013	Vincent; Jon	A63F13/54	381/17
*	I	US-20130208897-A1	08-2013	Vincent; Jon	A63F13/10	381/17
*	J	US-20130051566-A1	02-2013	PONTOPPIDAN; Niels Henrik	H04R25/353	381/23.1
*	K	US-20130051565-A1	02-2013	PONTOPPIDAN; Niels Henrik	H04R25/353	381/23.1
*	L	US-20120237037-A1	09-2012	Ninan; Ajit	H04S7/304	381/17
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*	B	US-20120121093-A1	05-2012	Araki; Junji	H04R3/14	381/17
*	C	US-20110293129-A1	12-2011	Dillen; Paulus Henricus Antonius	H04S7/304	381/370
*	D	US-20110103591-A1	05-2011	Ojala; Pasi	G10L19/008	381/17
*	E	US-20100329466-A1	12-2010	Berge; Svein	H04R3/12	381/22
*	F	US-20100241256-A1	09-2010	Goldstein; Steven	H04R5/04	700/94
*	G	US-20090046864-A1	02-2009	Mahabub; Jerry	H04S7/30	381/17
*	H	US-20080181418-A1	07-2008	Kim; Young-tae	H04S7/302	381/17
*	I	US-20080273708-A1	11-2008	Sandgren; Patrik	H04S1/005	381/63
*	J	US-20070270988-A1	11-2007	Goldstein; Steven W.	H04R5/04	700/94
*	K	US-20060274901-A1	12-2006	Terai; Kenichi	H04S1/005	381/17
*	L	US-20060056638-A1	03-2006	Schobben; Daniel Willem Elisabeth	H04S1/002	381/17
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*	B	US-20140193006-A1	07-2014	CHOI; Hyunsuk	H04S7/303	381/303
*	C	US-20100183159-A1	07-2010	Clot; Vincent	H04S7/30	381/56
*	D	US-20080159544-A1	07-2008	KIM; Sun-min	H04S3/00	381/1
*	E	US-20030007648-A1	01-2003	Currell, Christopher	H04S7/305	381/61
*	F	US-9649225-B2	05-2017	Kirsch; James M.	H04R1/1083	1/1
*	G	US-7085393-B1	08-2006	Chen; Jiashu	H04S1/007	381/1
*	H	US-6421446-B1	07-2002	Cashion; Terry	H04S1/005	381/17
*	I	US-5809149-A	09-1998	Cashion; Terry	H04S1/005	381/17
*	J	US-5598478-A	01-1997	Tanaka; Yoshiaki	H04S1/002	381/17
*	K	US-20180084359-A1	03-2018	Lyren; Philip Scott	G10L19/167	1/1
*	L	US-20180035238-A1	02-2018	Norris; Glen A.	H04R5/04	1/1
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*	B	US-20170339508-A1	11-2017	Norris; Glen A.	H04M1/72457	1/1
*	C	US-20170303061-A1	10-2017	Norris; Glen A.	H04M1/6033	1/1
*	D	US-20170272880-A1	09-2017	Norris; Glen A.	H04R5/04	1/1
*	E	US-20170188168-A1	06-2017	Lyren; Philip Scott	G10L19/167	1/1
*	F	US-20180048959-A1	02-2018	FUJII; Yumi	H04S1/00	1/1
*	G	US-20180027349-A1	01-2018	Osman; Steven	H04S7/304	381/303
*	H	US-20180014135-A1	01-2018	CHUNG; Hyun-joo	H04S3/008	1/1
*	I	US-9226090-B1	12-2015	Norris; Glen A.	H04M3/568	1/1
*	J	US-9918178-B2	03-2018	Norris; Glen A.	H04S1/002	1/1
*	K	US-9832588-B1	11-2017	Norris; Glen A.	H04M1/6033	1/1
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Notice of References Cited

Part of Paper No. 20210927

<i>Index of Claims</i> 	Application/Control No. 17/062,633	Applicant(s)/Patent Under Reexamination Lyren et al.
	Examiner YOGESHKUMAR G PATEL	Art Unit 2651

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

CLAIMS										
☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47										
CLAIM			DATE							
Final	Original	09/27/2021								
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Issue Classification 	Application/Control No. 17/062,633	Applicant(s)/Patent Under Reexamination Lyren et al.
	Examiner YOGESHKUMAR G PATEL	Art Unit 2651

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Symbol					Type	Version
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H04R	/	29	/	00	I	2013-01-01
G06K	/	9	/	00228	I	2013-01-01
G06F	/	3	/	013	I	2013-01-01
G06F	/	3	/	167	I	2013-01-01
G06F	/	3	/	011	I	2013-01-01
G06F	/	3	/	012	I	2013-01-01
G06K	/	9	/	00268	I	2013-01-01
H04S	/	7	/	301	I	2013-01-01
H04S	/	2420	/	01	A	2013-01-01
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CPC Combination Sets					
Symbol				Type	Version
/	/	/	/		

NONE		Total Claims Allowed:	
(Assistant Examiner)	(Date)	20	
/YOGESHKUMAR PATEL/ Primary Examiner, Art Unit 2651	27 September 2021	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	5

U.S. Patent and Trademark Office

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Issue Classification 	Application/Control No. 17/062,633	Applicant(s)/Patent Under Reexamination Lyren et al.
	Examiner YOGESHKUMAR G PATEL	Art Unit 2651

INTERNATIONAL CLASSIFICATION				
CLAIMED				
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H04S7/00	/	7	/	00
H04R29/00	/	29	/	00
G06K9/00	/	9	/	00
G06F3/01	/	3	/	01
G06F3/16	/	3	/	16
NON-CLAIMED				

US ORIGINAL CLASSIFICATION	
CLASS	SUBCLASS

CROSS REFERENCES(S)						
CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)					

NONE		Total Claims Allowed:	
(Assistant Examiner)	(Date)	20	
/YOGESHKUMAR PATEL/ Primary Examiner, Art Unit 2651	27 September 2021	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	5

U.S. Patent and Trademark Office

Part of Paper No.: 20210927

Issue Classification 	Application/Control No. 17/062,633	Applicant(s)/Patent Under Reexamination Lyren et al.
	Examiner YOGESHKUMAR G PATEL	Art Unit 2651

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47																
CLAIMS																
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U.S. Patent and Trademark Office

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<i>Search Notes</i> 	Application/Control No. 17/062,633	Applicant(s)/Patent Under Reexamination Lyren et al.
	Examiner YOGESHKUMAR G PATEL	Art Unit 2651

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H04S 1/005, 7/301, 7/302, 7/303, 7/304, 2420/01	09/27/2021	Y.P.
G06F 3/167, 3/011, 3/013, 3/012, 3/017	09/27/2021	Y.P.
06K 9/00268, 9/00228, 9/00288	09/27/2021	Y.P.
H04R 2499/11	09/27/2021	Y.P.

CPC Combination Sets - Searched*		
Symbol	Date	Examiner

US Classification - Searched*			
Class	Subclass	Date	Examiner

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	Date	Examiner
EAST with keywords	09/27/2021	Y.P.
CPC with keywords	09/27/2021	Y.P.
iP.com with concept and keywords	09/27/2021	Y.P.

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner
See Search History		09/27/2021	Y.P.

/YOGESHKUMAR PATEL/ Primary Examiner, Art Unit 2651	
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<i>Search Notes</i> 	Application/Control No. 17/062,633	Applicant(s)/Patent Under Reexamination Lyren et al.
	Examiner YOGESHKUMAR G PATEL	Art Unit 2651

/YOGESHKUMAR PATEL/ Primary Examiner, Art Unit 2651	
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Main Concept Document

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US20210021946

Title: Capturing Audio Impulse Responses of a Person with a Smartphone

Abstract: A portable electronic device (PED) divides an area around a user into a three-dimensional (3D) zone. A wearable electronic device worn on a head of the user displays the 3D zone in response to the wearable electronic device detecting that the user is leaving the zone. The wearable electronic device plays binaural sound that emanates to the user from sound localization points (SLPs) inside the zone.

(No Concept Modifiers)

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Filters (2)

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Publication Date: To 2016-02-20

Title+Abstract+Description+Claims+Related Terms limited to: Head Worn VR Sound Source Outside Zone Area

Options

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De-dup: None

Cut-off: None

Sort: Relevance

Content: Patent Publications (164)

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US Patents

US Designs

US Applications

EPO Patents

EPO Applications

China Patents

China Applications

Japan Patents

Japan Applications

Korea Patents

Korea Applications

WIPO Applications

Argentina Patents

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Brazil Patents
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El Salvador Applications
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Kazakhstan Patents
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Main Concept Document

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US20210021946

Title: Capturing Audio Impulse Responses of a Person with a Smartphone

(No Concept Modifiers)

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Filters (1)

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Publication Date: To 2016-02-20

Options

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De-dup: None

Cut-off: None

Sort: Relevance

Content: Patent Publications (164)

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US Patents

US Designs

US Applications

EPO Patents

EPO Applications

China Patents

China Applications

Japan Patents

Japan Applications

Korea Patents

Korea Applications

WIPO Applications

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Argentina Applications

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Brazil Applications

Canada Patents

Canada Applications

Chile Patents

Chile Applications

Colombia Applications

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Cuba Patents

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EAST Search History

EAST Search History (Prior Art)

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S2	185	((("NORRIS") near3 ("Glen"))).INV.	US-PGPUB; USPAT; USOCR	OR	OFF	2021/09/27 08:03
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S4	315	((Cell Cellular Electronic Mobile Portable Handheld) near2 (Phone Device)) PED HPED) same ((Area Zone Space Surroun\$4) with (SLP (sound near2 localiz\$5 near2 Point)))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2021/09/27 08:10
S5	233	S4 and ((binaural bi\$1aural) same ((Empty Void Distan\$2 Surroun\$4) near2 (Area Zone Space)))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2021/09/27 08:16
S6	174	S5 and ((Play Play\$3 Render Render\$3) near2 (WED Wearable Head\$1Worn (Head near Worn) Headset Head\$1Set HeadPhone Head\$1Phone Earbud Ear\$1bud Earphone Ear\$1phone))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2021/09/27 08:19
S7	131	S6 and ((Track Track\$3) with (Sensor Sens\$3 Compass Magnetometer Motion Gyroscope Accelerometer Inertial)) and ((Move\$4 Move Moving) with ((Empty Void Distan\$2 Surroun\$4 Outside Exten\$4) near2 (Area Zone Space)))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2021/09/27 08:28

S8	2	S7 and ((Displa\$4 with (WED Wearable Head\$1Worn (Head near Worn) Headset Head\$1Set HeadPhone Head\$1Phone Earbud Ear\$1bud Earphone Ear\$1phone)) same ((VR (Virtual near Reality)) near2 Image) with ((Empty Void Distan\$2 Surroun\$4 Outside Exten\$4) near2 (Area Zone Space))))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2021/09/27 08:37
S9	3	S7 and (Displa\$4 with ((VR (Virtual near Reality)) near2 Image) with ((Empty Void Distan\$2 Surroun\$4 Outside Exten\$4) near2 (Area Zone Space))))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2021/09/27 08:40
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EAST Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S33	0	(((((Cell Cellular Electronic Mobile Portable Handheld) near2 (Phone Device)) PED) and Divid\$3 and (Area Zone) and (SLP (sound near2 localiz\$5 near2 Point)) and (binaural bi\$1naural) and Empty and Space and (Play Play\$3) and (WED Wearable Head\$1Worn (Head near Worn) Headset Head\$1Set HeadPhone Head\$1Phone) and (Track Track\$3) and (Sensor Sens\$3) and	USPAT	OR	ON	2021/09/27 09:15

	(Move Moved Moving) and Displa\$4 and (VR (Virtual near Reality)) and Image).CLM.				
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9/27/2021 9:20:34 AM

C:\Users\ypatel2\Documents\EAST\Workspaces\17062633.wsp

Main Concept Document

=====

US20210021946

Title: Capturing Audio Impulse Responses of a Person with a Smartphone

Abstract: A portable electronic device (PED) divides an area around a user into a three-dimensional (3D) zone. A wearable electronic device worn on a head of the user displays the 3D zone in response to the wearable electronic device detecting that the user is leaving the zone. The wearable electronic device plays binaural sound that emanates to the user from sound localization points (SLPs) inside the zone.

(No Concept Modifiers)

=====

Filters (2)

=====

Publication Date: To 2016-02-20

Title+Abstract+Description+Claims+Related Terms limited to: Head Worn VR

Options

=====

De-dup: None

Cut-off: None

Sort: Relevance

Content: Patent Publications (164)

=====

US Patents

US Designs

US Applications

EPO Patents

EPO Applications

China Patents

China Applications

Japan Patents

Japan Applications

Korea Patents

Korea Applications

WIPO Applications

Argentina Patents

Argentina Applications

Brazil Patents

Brazil Applications
Canada Patents
Canada Applications
Chile Patents
Chile Applications
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Ecuador Applications
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Spain Patents
Spain Applications
Sweden Patents
Sweden Applications
Switzerland Patents
Switzerland Applications
Ukraine Patents
Yugoslavia/Serbia and Montenegro Patents

Yugoslavia/Serbia and Montenegro Applications

Armenia Patents

Australia Patents

Australia Applications

Cyprus Patents

Gulf Cooperation Council Patents

Hong Kong Patents

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India Applications

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Singapore Applications

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Taiwan Applications

Tajikistan Patents

Tajikistan Applications

Thailand Applications

Uzbekistan Patents

Vietnam Patents

Algeria Patents

ARIPO Patents

ARIPO Applications

Egypt Patents

Kenya Patents

Malawi Patents

Morocco Patents

Morocco Applications

OAPI Patents

South Africa Patents

Tunisia Applications

Zambia Patents

Zimbabwe Patents

EAPO Patents

EAPO Applications

Georgia Patents

Georgia Applications

Kazakhstan Patents

IQQueryQuickExport-202109242252

Kazakhstan Applications

Russia Patents

Russia Applications

Turkey Patents

Turkey Applications

Bibliographic Data

Application No: 17/062,633

Foreign Priority claimed: ☐ Yes ☒ No

35 USC 119 (a-d) conditions met: ☐ Yes ☒ No ☐ Met After Allowance

Verified and Acknowledged: /YOGESHKUMAR PATEL/

Examiner's Signature

Initials

Title:

Capturing Audio Impulse Responses of a Person with a Smartphone

FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
10/05/2020	381	2651	PSL-038 (CON 7)
RULE			

APPLICANTS

INVENTORS

Philip Scott Lyren, Bangkok, THAILAND

Glen A. Norris, Tokyo, JAPAN

CONTINUING DATA

This application is a CON of 16938936 07/25/2020 PAT 10798509

16938936 is a CON of 16558078 08/31/2019 PAT 10728682

16558078 is a CON of 16445268 06/19/2019 PAT 10602291

16445268 is a CON of 16162416 10/17/2018 PAT 10440489

16162416 is a CON of 15944796 04/04/2018 PAT 10117038

15944796 is a CON of 15424901 02/06/2017 PAT 9980072

15424901 is a CON of 15049071 02/20/2016 PAT 9591427

FOREIGN APPLICATIONS

IF REQUIRED, FOREIGN LICENSE GRANTED**

10/14/2020

**** SMALL ENTITY ****

STATE OR COUNTRY

THAILAND

ADDRESS

PHILIP S. LYREN, PC

289 Woodland Avenue

Wadsworth, OH 44281

UNITED STATES

FILING FEE RECEIVED

\$830

Issue Fee Transmittal Form

Application Number	Filing Date	First Named Inventor	Atty. Docket No.	Confirmation No.
17062633	05-Oct-2020	Philip Scott Lyren	PSL-038 (CON 7)	2402

Capturing Audio Impulse Responses of a Person with a Smartphone

Entity Status		Application Type	Art Unit	Class - Subclass	EXAMINER
Small		Utility under 35 USC 111(a)	2651	001000	
Issue Fee Due	Publication Due	Total Fee(s) Due		Date Due	Prev. Paid Fee
\$600	\$0	\$600		03-Jan-2022	\$0

Current Correspondence Address:

64021
PHILIP S. LYREN, PC

289 Woodland Avenue

Wadsworth OH 44281
UNITED STATES
216-539-0572
Philip_Lyren@yahoo.com

Current Indicated Fee Address:

☐ Change of correspondence address requested, system generated AIA/122-EFS form attached

☐ Fee Address indication requested, system generated SB/47-EFS form attached

2.Entity Status

Change in Entity Status

Applicant certifying micro entity status; system generated Micro Entity certification form attached. See 37 CFR 1.29.

Note: Absent a valid certification of micro entity status, issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment. If this box is checked, you will be prompted to choose a micro entity status on the gross income basis (37 CFR 1.29(a)) or the institution of higher education basis (37 CFR 1.29(d)), and make the applicable certification online.

O

Applicant asserting small entity status. See 37 CFR 1.27.

Note: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.

○ Applicant changing to regular undiscounted fee status.

Note: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

WEB IFEE 1.0

Document Description: Issue Fee Payment (PTO-85B)

3.The Following Fee(s) Are Submitted:☒ Issue Fee

I authorize USPTO to apply my previously paid issue fee to the current fees due

☐ Publication Fee

The Director is hereby authorized to apply my previously paid issue fee to the current fee due and to charge deficient fees to Deposit Account Number _____

☐ Advance Order - # of copies _____

If **in addition to** the payment of the issue fee amount submitted with this form, there are any discrepancies in any amount(s) due, the Director is authorized to charge any deficiency, or credit any overpayment, to Deposit Account Number _____ .

The **issue fee must be submitted** with this form. **If payment of the issue fee does not accompany this form, checking this box and providing a deposit account number will NOT be effective to satisfy full payment of the fee(s) due.**

4.Firm and/or Attorney Names To Be Printed**NOTE: If no name is listed, no name will be printed**

For printing on the patent front page, list to be displayed as entered

1.

2.

3.

5.Assignee Name(s) and Residence Data To Be Printed

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

Name	City	State	Country	Category
------	------	-------	---------	----------

6.Signature

I certify, in accordance with 37 CFR 1.4(d)(4) that I am an attorney or agent registered to practice before the Patent and Trademark Office who has filed and has been granted power of attorney in this application. I also certify that this Fee(s) Transmittal form is being transmitted to the USPTO via EFS-WEB on the date indicated below.

Signature	/Philip Lyren/	Date	10-01-2021
Name	Philip Scott Lyren	Registration Number	40709

Electronic Patent Application Fee Transmittal				
Application Number:		17062633		
Filing Date:		05-Oct-2020		
Title of Invention:		Capturing Audio Impulse Responses of a Person with a Smartphone		
First Named Inventor/Applicant Name:		Philip Scott Lyren		
Filer:		Philip Scott Lyren		
Attorney Docket Number:		PSL-038 (CON 7)		
Filed as Small Entity				
Filing Fees for Utility under 35 USC 111(a)				
Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Basic Filing:				
UTILITY APPL ISSUE FEE	2501	1	600	600
PUBL. FEE- EARLY, VOLUNTARY, OR NORMAL	1504	1	0	0
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
Total in USD (\$)				600

Electronic Acknowledgement Receipt	
EFS ID:	43932329
Application Number:	17062633
International Application Number:	
Confirmation Number:	2402
Title of Invention:	Capturing Audio Impulse Responses of a Person with a Smartphone
First Named Inventor/Applicant Name:	Philip Scott Lyren
Customer Number:	64021
Filer:	Philip Scott Lyren
Filer Authorized By:	
Attorney Docket Number:	PSL-038 (CON 7)
Receipt Date:	01-OCT-2021
Filing Date:	05-OCT-2020
Time Stamp:	20:15:37
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	DA
Payment was successfully received in RAM	\$600
RAM confirmation Number	E202101K15331551
Deposit Account	
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Issue Fee Payment (PTO-85B)	Web85b.pdf	62204	no	2
			b501489827959e4cfe838436a5877471fb5c705a		

Warnings:**Information:**

2	Fee Worksheet (SB06)	fee-info.pdf	40315	no	2
			3d772b1d048b54a67bfe44d4f7672794a6ab27a2		

Warnings:**Information:**

Total Files Size (in bytes):			102519
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This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Doc Code: DIST.E.FILE Document Description: Electronic Terminal Disclaimer - Filed		PTO/SB/26 U.S. Patent and Trademark Office Department of Commerce
Electronic Petition Request	TERMINAL DISCLAIMER TO OBTAIN A DOUBLE PATENTING REJECTION OVER A "PRIOR" PATENT	
Application Number	17062633	
Filing Date	05-Oct-2020	
First Named Inventor	Philip Lyren	
Attorney Docket Number	PSL-038 (CON 7)	
Title of Invention	Capturing Audio Impulse Responses of a Person with a Smartphone	
☒ Filing of terminal disclaimer does not obviate requirement for response under 37 CFR 1.111 to outstanding Office Action ☒ This electronic Terminal Disclaimer is not being used for a Joint Research Agreement.		
Owner	Percent Interest	
Philip Lyren	100%	
Glen Norris	100%	
The owner(s) with percent interest listed above in the instant application hereby disclaims, except as provided below, the terminal part of the statutory term of any patent granted on the instant application which would extend beyond the expiration date of the full statutory term of prior patent number(s) 10798509		

as the term of said prior patent is presently shortened by any terminal disclaimer. The owner hereby agrees that any patent so granted on the instant application shall be enforceable only for and during such period that it and the prior patent are commonly owned. This agreement runs with any patent granted on the instant application and is binding upon the grantee, its successors or assigns.

In making the above disclaimer, the owner does not disclaim the terminal part of the term of any patent granted on the instant application that would extend to the expiration date of the full statutory term of the prior patent, "as the term of said prior patent is presently shortened by any terminal disclaimer," in the event that said prior patent later:

- expires for failure to pay a maintenance fee;
- is held unenforceable;
- is found invalid by a court of competent jurisdiction;
- is statutorily disclaimed in whole or terminally disclaimed under 37 CFR 1.321;
- has all claims canceled by a reexamination certificate;
- is reissued; or
- is in any manner terminated prior to the expiration of its full statutory term as presently shortened by any terminal disclaimer.

☒ Terminal disclaimer fee under 37 CFR 1.20(d) is included with Electronic Terminal Disclaimer request.

☐ I certify, in accordance with 37 CFR 1.4(d)(4), that the terminal disclaimer fee under 37 CFR 1.20(d) required for this terminal disclaimer has already been paid in the above-identified application.

Applicant claims the following fee status:

☒ Small Entity

☐ Micro Entity

☐ Regular Undiscounted

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

THIS PORTION MUST BE COMPLETED BY THE SIGNATORY OR SIGNATORIES

I certify, in accordance with 37 CFR 1.4(d)(4) that I am:

☒ An attorney or agent registered to practice before the Patent and Trademark Office who is of record in this application

Registration Number 40709

☐ A sole inventor

☐ A joint inventor; I certify that I am authorized to sign this submission on behalf of all of the inventors as evidenced by the power of attorney in the application

☐ A joint inventor; all of whom are signing this request

Signature	/Philip Lyren/
Name	Philip Lyren

*Statement under 37 CFR 3.73(b) is required if terminal disclaimer is signed by the assignee (owner).
Form PTO/SB/96 may be used for making this certification. See MPEP § 324.

Electronic Patent Application Fee Transmittal				
Application Number:		17062633		
Filing Date:		05-Oct-2020		
Title of Invention:		Capturing Audio Impulse Responses of a Person with a Smartphone		
First Named Inventor/Applicant Name:		Philip Scott Lyren		
Filer:		Philip Scott Lyren		
Attorney Docket Number:		PSL-038 (CON 7)		
Filed as Small Entity				
Filing Fees for Utility under 35 USC 111(a)				
Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Basic Filing:				
STATUTORY OR TERMINAL DISCLAIMER	2814	1	170	170
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Extension-of-Time:				
Miscellaneous:				
Total in USD (\$)				170

Doc Code: DISQ.E.FILE

Document Description: Electronic Terminal Disclaimer – Approved

Application No.: 17062633

Filing Date: 05-Oct-2020

Applicant/Patent under Reexamination: Lyren

Electronic Terminal Disclaimer filed on September 15, 2021

☒ APPROVED

This patent is subject to a terminal disclaimer

☐ DISAPPROVED

Approved/Disapproved by: Electronic Terminal Disclaimer automatically approved by EFS-Web

U.S. Patent and Trademark Office

Electronic Acknowledgement Receipt	
EFS ID:	43767625
Application Number:	17062633
International Application Number:	
Confirmation Number:	2402
Title of Invention:	Capturing Audio Impulse Responses of a Person with a Smartphone
First Named Inventor/Applicant Name:	Philip Scott Lyren
Customer Number:	64021
Filer:	Philip Scott Lyren
Filer Authorized By:	
Attorney Docket Number:	PSL-038 (CON 7)
Receipt Date:	15-SEP-2021
Filing Date:	05-OCT-2020
Time Stamp:	08:39:30
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	DA
Payment was successfully received in RAM	\$170
RAM confirmation Number	E20219E939260751
Deposit Account	
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Terminal Disclaimer-Filed (Electronic)	eTerminal-Disclaimer.pdf	42445	no	3
			888dd16d74c92f926c8fe6c4fc0a9a4dc96ed9f2		

Warnings:**Information:**

2	Fee Worksheet (SB06)	fee-info.pdf	37926	no	2
			378c68ff7ccf9a4d8d80ceb998fa5f43370deb5		

Warnings:**Information:**

Total Files Size (in bytes):			80371
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This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
17/062,633	10/05/2020	Philip Scott Lyren	PSL-038 (CON 7)

CONFIRMATION NO. 2402

PUBLICATION NOTICE

64021
PHILIP S. LYREN, PC
289 Woodland Avenue
Wadsworth, OH 44281



Title:Capturing Audio Impulse Responses of a Person with a Smartphone

Publication No.US-2021-0021946-A1

Publication Date:01/21/2021

NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be accessed through the USPTO's publicly available Searchable Databases via the Internet at www.uspto.gov. The direct link to access the publication is currently <http://www.uspto.gov/patft/>.

The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Public Records Division. The Public Records Division can be reached by telephone at (571) 272-3150 or (800) 972-6382, by facsimile at (571) 273-3250, by mail addressed to the United States Patent and Trademark Office, Public Records Division, Alexandria, VA 22313-1450 or via the Internet.

In addition, information on the status of the application, including the mailing date of Office actions and the dates of receipt of correspondence filed in the Office, may also be accessed via the Internet through the Patent Electronic Business Center at www.uspto.gov using the public side of the Patent Application Information and Retrieval (PAIR) system. The direct link to access this status information is currently <https://portal.uspto.gov/pair/PublicPair>. Prior to publication, such status information is confidential and may only be obtained by applicant using the private side of PAIR.

Further assistance in electronically accessing the publication, or about PAIR, is available by calling the Patent Electronic Business Center at 1-866-217-9197.

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventors:	Philip S. Lyren, et al.	Examiner:	Yogeshkumar G Patel
Serial No.:	17/062,633	Group Art Unit:	2651
Filed:	5 October 2020	Docket No.:	PSL-038 (CON 7)
Title:	A wearable electronic device displays a 3D zone from where binaural sound emanates		

PRELIMINARY AMENDMENT FOR CONTINUING APPLICATION

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Amendments to the Drawings: Replacement Sheet

Figure 11 has a typographical error: Number 1600 pointing to a stack of books should be 1160. Applicants submit herewith a Replacement Sheet in which number 1600 is changed to number 1160. No other change is made to the drawings.

Amendments to the Specification

The Specification is amended to change the title and abstract.

Amendments to the Claims

Claims 1 – 20 are canceled. Claims 21 – 40 are newly added. No new matter is entered.

Respectfully submitted,

/Philip S. Lyren #40,709/

Philip S. Lyren
Reg. No. 40,709
Ph: 216-539-0572

Amendments to the Specification

Please amend the title of the invention as follows:

A wearable electronic device displays a 3D zone from where binaural sound emanates
~~Capturing Audio Impulse Responses of a Person with a Smartphone~~

Amendments to the Specification

Please amend the abstract of the invention as follows:

A portable electronic device (PED) divides an area around a user into a three-dimensional (3D) zone. A wearable electronic device worn on a head of the user displays the 3D zone in response to the wearable electronic device detecting that the user is leaving the zone. The wearable electronic device plays binaural sound that emanates to the user from sound localization points (SLPs) inside the zone. A
~~method captures audio impulse responses of a person wearing electronic microphones in a left ear and a right ear. A smartphone generates a sound while it is away from but proximate to the person. The microphones capture the audio impulse responses that are used to convolve sound so it localizes away from but proximate to the person.~~

Replacement Sheet

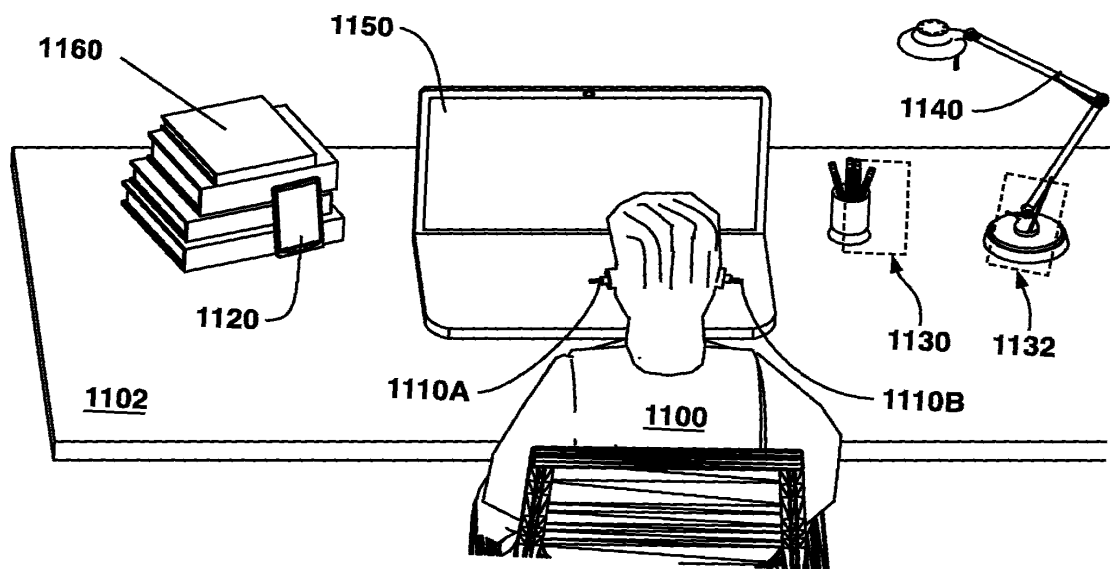


Figure 11

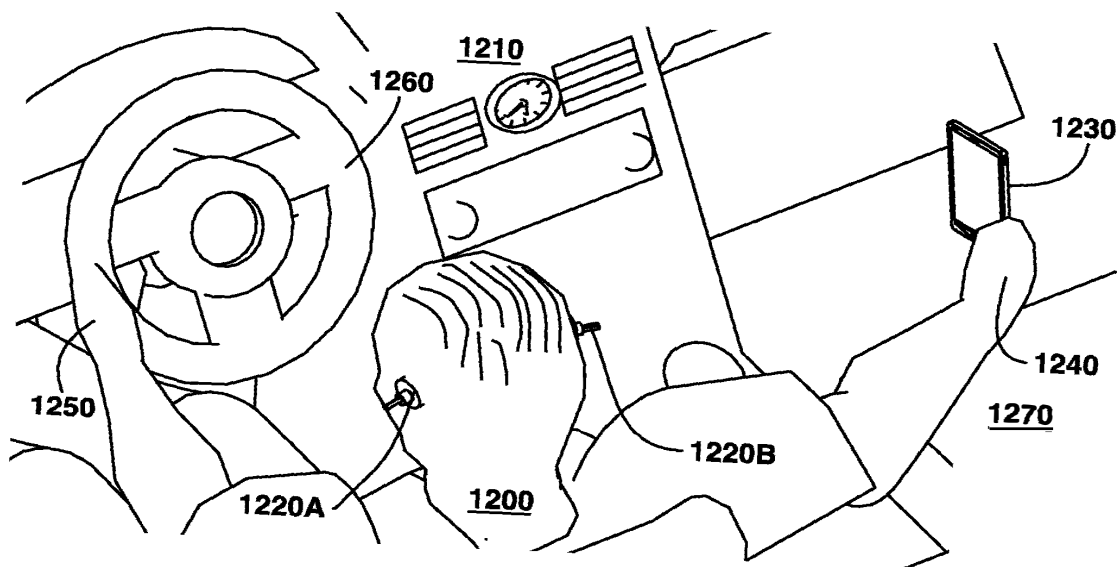


Figure 12

Amendments to the Claims

This listing of claims will replace all prior versions, and listings, of the claims:

1. – 20. (canceled)

21. (new) A method comprising:

dividing, with a portable electronic device (PED) held in a hand of a user, an area around the user into a zone that extends around the user and that includes a sound localization point (SLP) from where binaural sound in empty space originates to the user;

playing, with speakers in a wearable electronic device (WED) worn on a head of the user, the binaural sound that originates from the SLP in empty space;

tracking, with one or more sensors in the WED worn on the head of the user, the PED to determine when the PED held in the hand of the user is moving outside the zone that extends around the user; and

displaying, with the WED worn on the head of the user, a virtual reality (VR) image that shows the zone in response to the WED determining that the PED is moving outside the zone.

22. (new) The method of claim 21 further comprising:

highlighting, while the user is located inside the zone and with a display of the WED, a VR image at the SLP in the zone when the PED held in the hand of the user is pointed at the SLP in the zone; and

playing, with the WED worn on the head of the user, the binaural sound that emanates from the SLP in response to the PED pointing at the SLP.

23. (new) The method of claim 21 further comprising:

displaying, with the WED worn on the head of the user, the VR image that shows a size and a shape of the zone in response to the WED determining that the

PED is moving outside the zone.

24. (new) The method of claim 21 further comprising:

storing, in memory of the WED, a location of the zone, a size and a shape of the zone, and a location of the SLP in the zone from where the binaural sound originates to the user; and

retrieving, from the memory of the WED, the size and the shape of the zone in response to the WED determining that the user is in the location of the zone.

25. (new) The method of claim 21 further comprising:

designating, with the PED held in the hand of the user, locations of multiple SLPs in empty space in the zone from where the binaural sound originates to the user; and

displaying, with the WED, VR images at the locations of the multiple SLPs in empty space in the zone.

26. (new) The method of claim 21 further comprising:

selecting one of multiple SLPs in the zone when the PED held in the hand of the user is pointed at the one of the multiple SLPs in the zone; and

displaying, with the WED worn on the head of the user, a VR image at the one of the multiple SLPs in response to the one of the multiple SLPs being pointed at by the PED held in the hand of the user.

27. (new) The method of claim 21, wherein the zone has one of a three-dimensional (3D) shape of a cylinder and a 3D shape of a rectangle, and the user is centered in the zone.

28. (new) The method of claim 21 further comprising:

playing, with the speakers in the WED worn on the head of the user, an audio warning in response to the WED determining that the PED is moving outside the zone.

29. (new) A method comprising:

dividing, with a portable electronic device (PED) held in a hand of a user, an area around the user into a three-dimensional (3D) zone that extends around the user and that includes sound localization points (SLPs) from where binaural sound originates to the user;

determining, with a wearable electronic device (WED) worn on a head of the user, when the user is leaving the zone; and

warning the user that the user is leaving the zone by displaying, with the WED worn on the head of the user, a 3D virtual reality (VR) image of the zone in response to the WED determining that the user is leaving the zone.

30. (new) The method of claim 29 further comprising:

determining, with the WED, when the PED is pointed at one of the SLPs while the user is located in the zone; and

playing the binaural sound that originates from the one of the SLPs in the zone in response to the WED determining that the PED is pointed at the one of the SLPs.

31. (new) The method of claim 29 further comprising:

highlighting, while the user is located in the zone and with a display of the WED, color of a VR image at one of the SLPs in the zone when the PED held in the hand of the user points at the one of the SLPs in the zone.

32. (new) The method of claim 29, wherein the 3D VR image of the zone is shaped as a cylinder with the user being centered in the cylinder, and the WED is a head mounted display that display VR images and plays the binaural sound while the user plays a game.

33. (new) The method of claim 29, wherein the 3D VR image of the zone is shaped as a rectangle with the user being centered in the rectangle, and the WED is a head mounted display that displays VR images and plays the binaural sound while

the user plays a game.

34. (new) The method of claim 29 further comprising:

playing, with the WED worn on the head of the user, an audio warning indicating the user should move back into the zone in response to the WED determining that the user is leaving the zone.

35. (new) The method of claim 29, wherein the 3D VR image of the zone is shaped as a cylinder that extends around the user.

36. (new) The method of claim 29 further comprising:

determining, with the WED worn on the head of the user, when the PED is leaving the zone; and

warning the user that the PED is leaving the zone by displaying, with the WED worn on the head of the user, the 3D VR image of the zone in response to the WED determining that the PED is leaving the zone.

37. (new) An electronic system comprising:

a portable electronic device (PED) held in a hand of a user that divides an area around the user into a three-dimensional (3D) zone that extends around the user and includes sound localization points (SLPs) in empty space from where binaural sound originates to the user while the user is located inside the zone; and

a wearable electronic device (WED) that is worn on a head of the user, wirelessly communicates with the PED, includes speakers that play to the user the binaural sound that emanates from the SLPs in empty space inside the zone, includes one or more sensors that sense when the PED is leaving the zone, and includes a display that displays a virtual reality (VR) image of the zone in response to sensing that the PED is leaving the zone, wherein the display displays the VR image of the zone to warn the user that the user is leaving the zone.

38. (new) The electronic system of claim 37, wherein the display of the WED highlights a color of a VR image at one of the SLPs in response to the WED determining that the PED is pointing to the VR image at the one of the SLPs.

39. (new) The electronic system of claim 37, wherein the WED tracks a location of the user with respect to the SLPs, and automatically displays a VR image at a location of one of the SLPs in response to determining that the user is proximate to the location of the one of the SLPs.

40. (new) The electronic system of claim 37, wherein the speakers in the WED play the binaural sound that emanates from one of the SLPs in empty space in response to the WED determining that the PED is pointed to the one of the SLPs in empty space, and the zone is shaped as a 3D cylinder with the user being centered in the 3D cylinder.

Electronic Acknowledgement Receipt	
EFS ID:	40873509
Application Number:	17062633
International Application Number:	
Confirmation Number:	2402
Title of Invention:	Capturing Audio Impulse Responses of a Person with a Smartphone
First Named Inventor/Applicant Name:	Philip Scott Lyren
Customer Number:	64021
Filer:	Philip Scott Lyren
Filer Authorized By:	
Attorney Docket Number:	PSL-038 (CON 7)
Receipt Date:	18-OCT-2020
Filing Date:	05-OCT-2020
Time Stamp:	23:19:19
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment		no			
File Listing:					
Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Preliminary Amendment	cover.pdf	28255	no	1
			689a5fad34c101af73e327f51c167afa8ca67609		
Warnings:					

Information:					
2	Specification	specification.pdf	23516	no	2
			8cc699cfcfb347e9cf98f90fc43d72cfead85558		
Warnings:					
Information:					
3	Drawings-only black and white line drawings	Replacement_Sheet.pdf	67211	no	1
			e1b12dc2f5544f110b7826a9e079be55b121939f		
Warnings:					
Information:					
4	Claims	claims.pdf	47823	no	5
			875d4fff8d3ba2b217a31745ebec0e20a0451bdc		
Warnings:					
Information:					
Total Files Size (in bytes):			166805		
This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503. <u>New Applications Under 35 U.S.C. 111</u> If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application. <u>National Stage of an International Application under 35 U.S.C. 371</u> If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course. <u>New International Application Filed with the USPTO as a Receiving Office</u> If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.					

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875						Application or Docket Number 17/062,633			
APPLICATION AS FILED - PART I									
(Column 1)		(Column 2)		SMALL ENTITY		OR OTHER THAN SMALL ENTITY			
FOR	NUMBER FILED	NUMBER EXTRA	RATE(\$)	FEE(\$)		RATE(\$)	FEE(\$)		
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	80		N/A			
SEARCH FEE (37 CFR 1.16(k), (l), or (m))	N/A	N/A	N/A	350		N/A			
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	400		N/A			
TOTAL CLAIMS (37 CFR 1.16(i))	20 minus 20 =	*	x 50 =	0.00	OR				
INDEPENDENT CLAIMS (37 CFR 1.16(h))	3 minus 3 =	*	x 240 =	0.00					
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is \$310 (\$155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			0.00					
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				0.00					
* If the difference in column 1 is less than zero, enter "0" in column 2.				TOTAL		TOTAL			
				830					
APPLICATION AS AMENDED - PART II									
(Column 1)		(Column 2)		(Column 3)		SMALL ENTITY		OR OTHER THAN SMALL ENTITY	
AMENDMENT A	CLAIMS REMAINING AFTER AMENDMENT	HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE(\$)	ADDITIONAL FEE(\$)		RATE(\$)	ADDITIONAL FEE(\$)	
	Total (37 CFR 1.16(i))	*	Minus **	=	x =		x =		
	Independent (37 CFR 1.16(h))	*	Minus ***	=	x =		x =		
	Application Size Fee (37 CFR 1.16(s))								
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))								
				TOTAL ADD'L FEE		TOTAL ADD'L FEE			
AMENDMENT B	CLAIMS REMAINING AFTER AMENDMENT	HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE(\$)	ADDITIONAL FEE(\$)		RATE(\$)	ADDITIONAL FEE(\$)	
	Total (37 CFR 1.16(i))	*	Minus **	=	x =		x =		
	Independent (37 CFR 1.16(h))	*	Minus ***	=	x =		x =		
	Application Size Fee (37 CFR 1.16(s))								
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))								
				TOTAL ADD'L FEE		TOTAL ADD'L FEE			
* If the entry in column 1 is less than the entry in column 2, write "0" in column 3. ** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20". *** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3". The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.									



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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY. DOCKET NO	TOT CLAIMS	IND CLAIMS
17/062,633	10/05/2020		830	PSL-038 (CON 7)	20	3

CONFIRMATION NO. 2402

FILING RECEIPT



CC000000120640124

64021
PHILIP S. LYREN, PC
289 Woodland Avenue
Wadsworth, OH 44281

Date Mailed: 10/14/2020

Receipt is acknowledged of this non-provisional utility patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF FIRST INVENTOR, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection.

Please verify the accuracy of the data presented on this receipt. If an error is noted on this Filing Receipt, please submit a written request for a corrected Filing Receipt, including a properly marked-up ADS showing the changes with strike-through for deletions and underlining for additions. If you received a "Notice to File Missing Parts" or other Notice requiring a response for this application, please submit any request for correction to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections provided that the request is grantable.

Inventor(s)

Philip Scott Lyren, Bangkok, THAILAND;
Glen A. Norris, Tokyo, JAPAN;

Applicant(s)

Philip Scott Lyren, Bangkok, THAILAND;
Glen A. Norris, Tokyo, JAPAN;

Power of Attorney:

Philip Lyren--40709

Domestic Priority data as claimed by applicant

This application is a CON of 16/938,936 07/25/2020 PAT 10798509
which is a CON of 16/558,078 08/31/2019 PAT 10728682
which is a CON of 16/445,268 06/19/2019 PAT 10602291
which is a CON of 16/162,416 10/17/2018 PAT 10440489
which is a CON of 15/944,796 04/04/2018 PAT 10117038
which is a CON of 15/424,901 02/06/2017 PAT 9980072
which is a CON of 15/049,071 02/20/2016 PAT 9591427

Foreign Applications for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see <http://www.uspto.gov> for more information.) - None.

Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: No

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

If Required, Foreign Filing License Granted: 10/14/2020

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 17/062,633**

Projected Publication Date: 01/21/2021

Non-Publication Request: No

Early Publication Request: No

**** SMALL ENTITY ****

Title

Capturing Audio Impulse Responses of a Person with a Smartphone

Preliminary Class

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at <http://www.uspto.gov/web/offices/pac/doc/general/index.html>.

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UTILITY PATENT APPLICATION TRANSMITTAL <i>(Only for new nonprovisional applications under 37 CFR 1.53(b))</i>	Attorney Docket No.	PSL-038 (CON 7)
	First Inventor	Philip Scott Lyren
	Title	Capturing Audio Impulse Responses of a Person with a Smartphone
	Express Mail Label No.	

APPLICATION ELEMENTS <i>See MPEP chapter 600 concerning utility patent application contents.</i>	ADDRESS TO: Commissioner for Patents P.O. Box 1450 Alexandria VA 22313-1450
1. ☐ Fee Transmittal Form. (PTO/SB/17 or equivalent) 2. ☒ Applicant claims small entity status. See 37 CFR 1.27. 3. ☒ Specification. [Total Pages <u>80</u>] Both the claims and abstract must start on a new page (For information on the preferred arrangement, see MPEP § 608.01(a)) 4. ☒ Drawing(s). (35 U.S.C. 113) [Total Sheets <u>14</u>] 5. Inventor's Oath or Declaration. [Total Sheets <u>3</u>] (including substitute statements under 37 CFR 1.64 and assignments serving as an oath or declaration under 37 CFR 1.63(e)) a. ☒ Newly executed (original or copy) b. ☐ A copy from a prior application (37 CFR 1.63(d)) 6. ☒ Application Data Sheet. *See Note below. See 37 CFR 1.76 (PTO/AIA/14 or equivalent) 7. ☐ CD-ROM or CD-R. in duplicate, large table or Computer Program (Appendix) ☐ Landscape Table on CD 8. Nucleotide and/or Amino Acid Sequence Submission. (if applicable, items a. – c. are required) a. ☐ Computer Readable Form (CRF) b. ☐ Specification Sequence Listing on: i. ☐ CD-ROM or CD-R (2 copies); or ii. ☐ Paper c. ☐ Statements verifying identity of above copies	ACCOMPANYING APPLICATION PARTS 9. ☐ Assignment Papers. (cover sheet & document(s)) Name of Assignee _____ 10. ☐ 37 CFR 3.73(c) Statement. ☒ Power of Attorney. (when there is an assignee) 11. ☐ English Translation Document. (if applicable) 12. ☐ Information Disclosure Statement. (PTO/SB/08 or PTO-1449) ☐ Copies of citations attached 13. ☐ Preliminary Amendment. 14. ☐ Return Receipt Postcard. (MPEP § 503) (Should be specifically itemized) 15. ☐ Certified Copy of Priority Document(s). (if foreign priority is claimed) 16. ☐ Nonpublication Request. Under 35 U.S.C. 122(b)(2)(B)(i). Applicant must attach form PTO/SB/35 or equivalent. 17. ☐ Other: _____

***Note:** (1) Benefit claims under 37 CFR 1.78 and foreign priority claims under 1.55 **must** be included in an Application Data Sheet (ADS).
(2) For applications filed under 35 U.S.C. 111, the application must contain an ADS specifying the applicant if the applicant is an assignee, person to whom the inventor is under an obligation to assign, or person who otherwise shows sufficient proprietary interest in the matter. See 37 CFR 1.46(b).

18. CORRESPONDENCE ADDRESS					
☒ The address associated with Customer Number: <u>64021</u> OR ☐ Correspondence address below					
Name					
Address					
City		State		Zip Code	
Country		Telephone		Email	
Signature		/Philip Lyren, #40,709/		Date 4 October 2020	
Name (Print/Type)		Philip Lyren		Registration No. (Attorney/Agent) 40,709	

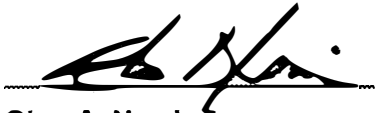
This collection of information is required by 37 CFR 1.53(b). The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

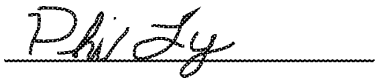
**POWER OF ATTORNEY TO PROSECUTE APPLICATIONS BEFORE THE
USPTO**

As a named inventor, we hereby appoint Philip Scott Lyren (attorney having registration number 40,709) to prosecute the patent application having attorney docket number PSL-038 (CON) (entitled "Capturing Audio Impulse Responses of a Person with a Smartphone") and to transact all business in the Patent and Trademark Office connected therewith.

IN WITNESS WHEREOF, I hereunto set my hand:


Glen A. Norris

15 October 2018
Date


Philip Scott Lyren

15 October 2018
Date

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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	PSL-038 (CON 7)
		Application Number	
Title of Invention	Capturing Audio Impulse Responses of a Person with a Smartphone		
The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76. This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.			

Secrecy Order 37 CFR 5.2

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Inventor Information:

Inventor	1				Remove	
Legal Name						
Prefix	Given Name	Middle Name	Family Name	Suffix		
	Philip	Scott	lyren			
Residence Information (Select One) US Residency ☒ Non US Residency Active US Military Service						
City	Bangkok	Country of Residence	TH			
Mailing Address of Inventor:						
Address 1	289 Woodland Avenue					
Address 2						
City	Wadsworth	State/Province	OH			
Postal Code	44281	Country	US			
Inventor	2				Remove	
Legal Name						
Prefix	Given Name	Middle Name	Family Name	Suffix		
	Glen	A.	Norris			
Residence Information (Select One) US Residency ☒ Non US Residency Active US Military Service						
City	Tokyo	Country of Residence	JP			
Mailing Address of Inventor:						
Address 1	1244 Arlington Road					
Address 2						
City	Lakewood	State/Province	OH			
Postal Code	44107	Country	US			
All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the Add button.						

Correspondence Information:

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	PSL-038 (CON 7)
		Application Number	
Title of Invention	Capturing Audio Impulse Responses of a Person with a Smartphone		

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

☐ An Address is being provided for the correspondence information of this application.

Customer Number	64021		
Email Address	philip_lyren@yahoo.com	Add Email	Remove Email

Application Information:

Title of the Invention	Capturing Audio Impulse Responses of a Person with a Smartphone		
Attorney Docket Number	PSL-038 (CON 7)	Small Entity Status Claimed	☒
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	14	Suggested Figure for Publication (if any)	

Filing By Reference :

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	PSL-038 (CON 7)
		Application Number	
Title of Invention	Capturing Audio Impulse Responses of a Person with a Smartphone		

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Prior Application Status		Pending	Remove			
Application Number		Continuity Type		Prior Application Number	Filing Date (YYYY-MM-DD)	
		Continuation of		16938936	2020-07-25	
Prior Application Status		Patented	Remove			
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)	
16938936	Continuation of	16558078	2019-08-31	10728682	2020-07-28	
Prior Application Status		Patented	Remove			
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)	
16558078	Continuation of	16445268	2019-06-19	10602291	2020-03-24	
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16445268	Continuation of	16162416	2018-10-17	10440489	2019-10-08	
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16162416	Continuation of	15944796	2018-04-04	10117038	2018-10-30	
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15944796	Continuation of	15424901	2017-02-06	9980072	2018-05-22	
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15424901	Continuation of	15049071	2016-02-20	9591427	2017-03-07	
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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	PSL-038 (CON 7)
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Title of Invention	Capturing Audio Impulse Responses of a Person with a Smartphone		

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Application Number	Country ⁱ	Filing Date (YYYY-MM-DD)	Access Code ⁱ (if applicable)	Remove

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Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.

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Authorization to Permit Access:

☐ Authorization to Permit Access to the Instant Application by the Participating Offices

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	PSL-038 (CON 7)
		Application Number	
Title of Invention	Capturing Audio Impulse Responses of a Person with a Smartphone		

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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	PSL-038 (CON 7)	
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Signature	/Philip Lyren, #40,709/			Date (YYYY-MM-DD)	2020-10-04
First Name	Philip	Last Name	Lyren	Registration Number	40709
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		First Named Inventor	Philip Scott Lyren
☒ Declaration Submitted With Initial Filing OR ☐ Declaration Submitted After Initial Filing (surcharge (37 CFR 1.16(f)) required)		COMPLETE IF KNOWN	
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Capturing Audio Impulse Responses of a Person with a Smartphone

(Title of the Invention)

As a below named inventor, I hereby declare that:

This declaration is directed to:

☒ The attached application,

OR

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The above-identified application was made or authorized to be made by me.

I believe I am the original inventor or an original joint inventor of a claimed invention in the application.

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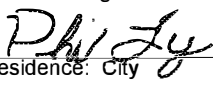
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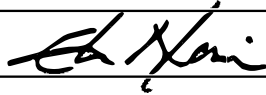
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LEGAL NAME OF SOLE OR FIRST INVENTOR:			
(E.g., Given Name (first and middle (if any)) and Family Name or Surname)			
Philip Scott Lyren			
Inventor's Signature 		Date (Optional) 4 October 2020	
Residence: City Bangkok	State	Country Thailand	
Mailing Address 289 Woodland Avenue			
City Wadsworth	State OH	Zip 44281	Country U.S.A.
☒ Additional inventors are being named on the <u>one</u> supplemental sheet(s) PTO/AIA/10 attached hereto			

DECLARATION	ADDITIONAL INVENTOR(S) Supplemental Sheet
Page <u>one</u> of <u>one</u>	

Name of Additional Joint Inventor, if any:		☐ A petition has been filed for this unsigned inventor	
Given Name (first and middle (if any))		Family Name or Surname	
Glen A		Norris	
Inventor's Signature 		15 October 2018 Date	
Tokyo Residence: City	State	Japan Country	U.S.A. Citizenship
1244 Arlington Road Mailing Address			
Lakewood City	Ohio State	44107 Zip	U.S.A. Country
Name of Additional Joint Inventor, if any:		☐ A petition has been filed for this unsigned inventor	
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Capturing Audio Impulse Responses of a Person with a Smartphone

BACKGROUND

[01] People are able to localize binaural sound by sensing audio cues in the form of temporal and spectral differences heard between the left and right ears. These differences can be artificially created using Head Related Transfer Functions (HRTFs). **HRTF's are individualized or unique functions for each person since they depend on a size and a shape of a person's head, face, ears, torso, and other physiological factors.**

[02] Unfortunately, it is difficult or burdensome to obtain the HRTFs for an individual. Typically, the HRTFs of a person must be measured in an anechoic chamber or a specialized location that includes numerous speakers, expensive sound equipment, and a soundproof environment.

[03] Methods and apparatus that facilitate obtaining HRTFs and audio impulse responses will advance technology that creates and maintains virtual environments, virtual reality, and augmented reality.

BRIEF DESCRIPTION OF THE DRAWINGS

[04] Figure 1 is a method to generate audio impulse responses from a sound generated or triggered with a hand-held portable electronic device (HPED) in accordance with an example embodiment.

[05] Figure 2 is a method to provide binaural sound to a person at a SLP that is away from but proximate to the person in accordance with an example embodiment.

[06] Figure 3 is a method to capture impulse responses when an HPED is within a certain distance of a person in accordance with an example embodiment.

[07] Figure 4 is a method to determine a facial orientation of a listening person when an audio impulse response is recorded in accordance with an example embodiment.

[08] Figure 5 is a method to designate one or more SLPs to a zone or area around a head of a person in accordance with an example embodiment.

[09] Figure 6 is a method to map a SLP to a location in accordance with an example embodiment.

[010] Figure 7 is a method to select a SLP for a person and convolve sound to localize at the SLP in accordance with an example embodiment.

[011] Figure 8 is a method to retrieve RIRs and convolve sound based on a location of a person in accordance with an example embodiment.

[012] Figure 9A is a top view of a person capturing audio impulse responses in accordance with an example embodiment.

[013] Figure 9B is a back view of the person of Figure 9A in accordance with an example embodiment.

[014] Figure 9C is a side view of the person of Figure 9A in accordance with an example embodiment.

[015] Figure 9D is a top corner view of the person of Figure 9A in accordance with an example embodiment.

[016] Figure 10A is a top view of a person capturing audio impulse responses with a HPED attached to a pole in accordance with an example embodiment.

[017] Figure 10B is a front view of the person of Figure 10A in accordance with an example embodiment.

[018] Figure 10C is a side view of the person of Figure 10A in accordance with an example embodiment.

[019] Figure 10D is a top corner view of the person of Figure 10A in accordance with an example embodiment.

[020] Figure 11 shows a person sitting at a table and capturing audio impulse responses with microphones in his left and right ears in accordance with an example embodiment.

[021] Figure 12 shows a person sitting in an automobile and capturing audio impulse responses with microphones in his left and right ears in accordance with an example embodiment.

[022] Figure 13 shows a person sitting in a chair at a table and being surrounded by a plurality of SLPs that are located away from but proximate to his face in accordance with an example embodiment.

[023] Figure 14 is an electronic system in accordance with an example embodiment.

[024] Figure 15 is another electronic system in accordance with an example embodiment.

[025] Figure 16 shows an electronic system that includes a HPED and a separate speaker attached to a pole in accordance with an example embodiment.

SUMMARY OF THE INVENTION

[026] One example embodiment is a method that captures audio impulse responses using electronic microphones in a left ear and a right ear of a person. A handheld portable electronic device (HPED) generates or triggers a sound away from but proximate to the person. The microphones capture the audio impulse responses that are used to convolve sound that localizes away from but proximate to the person.

[027] Other example embodiments are discussed herein.

DETAILED DESCRIPTION

[028] Example embodiments relate to methods and apparatus that generate, manage, and perform tasks for audio impulse responses, including room impulse responses (RIRs), binaural room impulse responses (BRIRs), head-related impulse responses (HRIRs), and head-related transfer functions (HRTFs).

[029] As noted in the Background section, it is difficult or burdensome to obtain HRTFs of a person. **Deriving a person's HRTFs with traditional methods can be time consuming and expensive.** Further, facilities to perform such measurements are not abundant and generally not accessible to the general public.

[030] In some instances, HRTFs for a person are not derived from data taken directly from the person but are derived from one or more approximation techniques, such as obtaining HRTFs from a dummy head or approximating HRTFs from HRTFs individualized for another person. These approximated HRTFs are not as accurate as HRTFs measured directly from the person.

[031] If the HRTFs are not sufficiently accurate for the person, then the person may localize sounds to the wrong location, such as localizing a sound toward the back of the head when the localization point is toward the front of the head. Additionally, if the HRTFs are not accurate, then the listener can fail to localize sounds externally and instead hear the sounds as if they originate inside the head of the listener.

[032] Example embodiments include systems, apparatus, and methods that capture head related transfer functions (HRTFs) of a person and solve problems associated with binaural sound, including problems related to obtaining accurate HRTFs for a person. With example embodiments, the HRTFs are individualized or unique for the person and can be used to accurately localize binaural sound.

[033] By way of introduction, sound localization (i.e., the act of relating attributes of the sound being heard by the listener to the location of an auditory event) provides the listener with a three-dimensional (3D) soundscape or 3D sound environment where sounds can be externally localized to points around the listener, such as external positions to which the listener can point. Binaural sound and some forms of stereo sound provide a listener with the ability to localize sound; though binaural sound generally provides a listener with a superior ability to localize sounds in 3D space.

[034] Sound localization offers people a wealth of new technological avenues to not only communicate with each other but also to communicate with electronic devices, software programs, and processes. This technology has broad applicability in augmented reality (AR), virtual reality (VR), audio augmented reality (AAR), telecommunications and communications, entertainment, tools and services for security, medicine, disabled persons, recording industries, education, natural language interfaces, and many other sectors.

[035] As this technology develops, challenges will arise with regard to how sound localization integrates into the modern era. Example embodiments offer solutions to some of these challenges and assist in providing technological advancements in methods and apparatus using sound localization.

[036] Binaural sound can be manufactured or recorded. When binaural sound is recorded, two microphones are placed in or near human ears or placed in ears of a dummy head. When this binaural recording is played back (e.g., through headphones or earphones), audio cues in the recorded sound provide the listener with an audio representation of the 3D space where the recording was made. The sound is quite realistic, and the listener can localize sources of individual sounds with a high degree of accuracy.

[037] Binaural sound typically delivers two types of localization cues: temporal cues and spectral cues. Temporal cues arise from an interaural time difference (ITD) due to the

distance between the ears. Spectral cues arise from an interaural level difference (ILD) or interaural intensity difference (IID) due to shadowing of sound around the head. Spatial cues are ITDs and ILDs and their combination.

[038] A person hearing the spatial cues can localize sound or estimate a location of a source of the sound. In some instances, a listener can externalize and localize a source of binaural sound to a point and experience the sound as indistinguishable from a real-world sound source occurring in his physical environment. Processing sounds through a **listener's individualized HRTFs** provides a markedly higher degree of realism than using approximated or stock HRTFs.

[039] Although stereo sound offers some degree of sound localization, stereo sound and binaural sound are different. As explained in WIKIPEDIA, the term "binaural sound" and **"stereo sound" are frequently confused as synonyms. Conventional stereo recordings do not factor in natural ear spacing or "head shadow" of the head and ears since these things happen naturally as a person listens and experiences his or her own ITDs (interaural time differences) and ILDs (interaural level differences). Headphones or earphones generally deliver binaural sound; although it can be delivered with loudspeakers. Loudspeaker-crosstalk of conventional stereo interferes with binaural reproduction, playback systems implement crosstalk cancellation to create a sweet spot for binaural listening. As a general rule, binaural sound accommodates for one or more ITDs, ILDs, natural ear spacing, and head shadow. The effects of these on a source signal can be derived from an individual's HRTF. Binaural sound can also be explained as causing or intending to cause one or more sound sources produced through headphones or earphones as originating apart from but proximate to the listener.**

[040] Binaural sound spatialization can be reproduced to a listener using headphones or speakers, such as with dipole stereo (e.g., multiple speakers that execute crosstalk cancellation). Generally, binaural playback on earphones or a specially designed stereo system provides the listener with a sound that spatially exceeds normally recorded stereo sound since the binaural sound more accurately reproduces the natural sound a user

hears when at the location where the sound was recorded. Binaural recordings can convincingly reproduce the location of sound behind, ahead, above, or any position the sound actually came from during recording.

[041] Sound signals are modified as they travel from their original source and interact with the human anatomy and surrounding environment. These modifications encode the location of the original source and can be captured as an impulse response. The impulse response for a human is called a head-related impulse response (HRIR), and it represents impulse responses from a sound source to two ears in a free-field environment (without modification due to a room environment). A HRTF is a Fourier transform of a HRIR.

[042] A source sound can be convolved with a HRIR of a person. Convolution of sound in this manner joins the original sound with impulse responses so the person hears the sound as if he or she were present at the source location when the sound was played. The HRIRs describe how to alter the sound source before the sound is provided to the ears of the listener.

[043] Impulse responses for a room or a particular location are room impulse responses or RIRs, whereas impulse responses for a room as experienced by a particular person in the room with two ears are binaural room impulse responses or BRIRs. For example, BRIRs characterize the transfer of sound from a source location in a room to the entrances of the left and right ears of a listener (such as a person or a dummy-head). BRIRs can be obtained by measuring RIRs and HRIRs separately or simultaneously. Further, BRIRs, HRIRs, and RIRs can be obtained without measuring, such as being generated from computer modeling of impulse responses. As one example, RIRs and HRIRs are measured with microphones at one or more locations. As another example, RIRs and HRIRs are generated with one or more computer models. As yet another example, HRIRs are measured with microphones; RIRs are generated with a computer model; and HRIRs and RIRs are combined to generate BRIRs. As yet another example, individualized or customized HRIRs and/or HRTFs are generated from measurements

and/or calculations based on an anthropometry-based method or subjective-selection-based method (such as customizing HRTFs for a person based on anatomical feature similarities of an individual with known, measured HRTFs of another individual). Transfer functions and impulse responses can also be generated from one or more interpolation techniques (such as interpolating a HRTF at a location between two known HRTFs or using a nearest known or measured location). Furthermore, impulse responses can be extracted to generate transfer functions, such as removing RIRs from a set of BRIRs to yield HRIRs/HRTFs or removing impulse responses due to a person's outstretched arm while holding the HPED to generate the sound.

[044] Figure 1 is a method to generate audio impulse responses from a sound generated or triggered with a hand-held portable electronic device (HPED).

[045] Block 100 states generate, from a speaker of a HPED, a sound while the HPED is at a location that is away from but proximate to a face of a person wearing earphones with microphones.

[046] Each ear of the person includes a microphone (i.e., the left ear has a microphone, and the right ear has a microphone). The earphones can include one or more of microphones, speakers, volume control, an on/off switch or power button, wireless communication circuitry, noise cancellation circuitry, etc. For example, the earphones include a left earphone with a left microphone and a left speaker and also include a right earphone with a right microphone and a right speaker.

[047] The earphones can directly connect to the HPED or wirelessly communicate with the HPED and/or a wireless network. For example, the earphones transmit and receive data over the Internet through a wireless network.

[048] Further, example embodiments are not limited to earphones but include other electronic devices with microphones that can be positioned in or near an ear of a person or dummy or otherwise record impulse responses. Examples of such devices with

microphones include, but are not limited to, headphones, wearable electronic glasses, optical head mounted displays (OHMDs), heads-up displays, and other electronic devices with microphones that can record impulse responses or sound.

[049] The speaker of the HPED plays or generates a sound that is used to determine audio impulse responses of the person and/or the room or environment where the person is located. By way of example, these impulse responses include one or more of HRIRs, BRIRs, and room impulse responses (RIRs).

[050] Further, example embodiments are not limited to a HPED that generates the sound but include other devices that can generate a sound to record audio impulse responses for a person. For example, the HPED communicates with and/or triggers another device to play sound. Examples of devices that can generate a sound include, but are not limited to, wearable electronic devices, televisions, desktop computers, speakers, and other electronic devices that generate sound. Further, such sound generating devices can be non-electronic devices such as clickers, and include people (such as a person generating a sound by clapping, snapping fingers, knocking, or talking).

[051] In an example embodiment, the sound generates left and right audio impulse responses that can be used to generate individualized or user-specific sets of HRTFs, HRIRs, or BRIRs. Different types of sounds can be used to generate these audio impulse responses. By way of example, such sounds include, but are not limited to, a known spectrum stimulus sound, a frequency-swept sine wave, a click, a pulse, a maximum length sequence (MLS), a pseudo-random binary sequence, a ping, a complementary Golay code, a voice announcing a word or a phrase, or another type of sound.

[052] The HPED generates or triggers the sound while the HPED is away from but proximate to the face of the person wearing earphones with microphones (or other electronic device as noted herein). A distance from the face of the person to the HPED can range from a few inches to several meters. Preferably, this distance is sufficient so audio impulse responses can be generated from the sound and used to subsequently

convolve sound so it externally localizes to the listener. For example, the HPED is positioned away from the person at a distance and angle such that the sound it generates **provides microphones in a person's ears with sufficient impulse responses to generate a set of HRTFs, HRIRs, or BRIRs for the person.** When this set is used to convolve a voice signal, the person localizes the voice to a point proximate but away from him, such as localizing sound to a SLP in empty space or localizing sound to a SLP on an object.

[053] A HRTF is a function of frequency (f) and three spatial variables (r , θ , ϕ) in a spherical coordinate system. Here, r is the radial distance from an origin of the sound to the recording point; θ (theta) is the azimuth angle between the origin and recording point; and ϕ (phi) is the polar angle, elevation, or elevation angle between the origin and recording point.

[054] When the distance (r) is greater than or equal to about one meter (1 m) as measured from the sound source to the capture point (e.g., the head of the person), the sound attenuates inversely with the distance. One meter or thereabout defines a **boundary between near field and far field HRTFs. A "near field" HRTF is measured from about one meter or less; whereas a "far field" HRTF is measured from about one meter or more.** Example embodiments can be implemented with near field and far field distances.

[055] Block 110 states capture, with a left microphone of the earphones in a left ear of the person and with a right microphone of the earphones in a right ear of the person, the sound generated from the speaker of the HPED.

[056] The left microphone captures the sound at the left ear, and the right microphone captures the sound at the right ear. Further, as noted, the earphones can be electrically connected to and/or in communication with an electronic device, such as being physically coupled or connected to a sound jack on the HPED or being in wireless communication with the HPED, a network, a server, or another electronic device.

[057] Block 120 states generate, from the sound captured in the left and right

microphones, a set of audio impulse responses or audio transfer functions for the person.

[058] When the microphones are positioned in the ears of the listening person, the HPED generates the sound while being at a distance (r) from the head of the person, at an azimuth angle (θ), and at an elevation angle (ϕ) (i.e., being at (r, θ, ϕ)). The captured sound is processed to generate one or more sets of HRTFs, HRIRs, RIRs, and BRIRs for the person and/or the location.

[059] During the processing, aspects of the measured impulse responses can be removed. For example, impulse responses attributed to the earphones (known as common transfer functions or CTFs) to yield a head related transfer function (HRTF) or directional transfer function (DTF) for the location from where the sound was generated. CTFs are also known as headphone or earphone transfer functions and can also be measured and appropriately inverted.

[060] Consider an example for calculating a HRTF or DTF for a known audio signal $s(t)$ that generates from a speaker of a HPED at a position (distance, azimuth, elevation) or (r, θ, ϕ) . The calculations below are for the left (l) ear, but are equally applicable to the right ear:

$$m_{l,\theta,\phi}(t) = s(t) \cdot c(t) \cdot d_{l,\theta,\phi}(t);$$

$$M_{l,\theta,\phi}(\omega) = S(\omega)C(\omega)D_{l,\theta,\phi}(\omega).$$

[061] Here, $m_{l,\theta,\phi}(t)$ is the signal recorded with the microphone of the left ear given the original known sound, $s(t)$; $c(t)$ is the known common transfer function or CTF; and $d_{l,\theta,\phi}(t)$ is the unknown directional transfer function for the left ear. As such, the signal recorded at the left ear is a function of the known original signal, the CTF, and the

unknown directional transfer function at the (r, θ, ϕ) , with the distance (r) being one meter or greater or measured for a far field HRTF.

[062] The above equations are rewritten to solve for $d_{l,\theta,\phi}(t)$ as follows:

$$|D_{l,\theta,\phi}(\omega)| = |M_{l,\theta,\phi}(\omega)| / (|S(\omega)|)(|C(\omega)|);$$

$$\angle D_{l,\theta,\phi}(\omega) = \angle M_{l,\theta,\phi}(\omega) - \angle S(\omega) - \angle C(\omega);$$

$$D_{l,\theta,\phi}(\omega) = |D_{l,\theta,\phi}(\omega)| \exp(j\angle D_{l,\theta,\phi}(\omega));$$

$$d_{l,\theta,\phi}(t) = F^{-1}(D_{l,\theta,\phi}(\omega)).$$

[063] The corresponding directional transfer function for the right ear would thus be:

$$d_{r,\theta,\phi}(t) = F^{-1}(D_{r,\theta,\phi}(\omega)).$$

[064] Following the derivation, the HRTFs can be stored in the AES69 spatial acoustic data file format.

[065] Figure 2 is a method to provide binaural sound to a person at a SLP that is away from but proximate to the person.

[066] Block 200 states obtain sound to provide to a person wearing earphones.

[067] One or more electronic devices capture or provide the sound. The sound can be

delivered over a wired or wireless network, from a server, or from a computer or local electronic device. Some example sources of the sound include, but are not limited to, sound streamed and provided in real-time from a telephony application or a live video call, sound provided by a computer program such as a multiplayer game with voices of other people, characters, and sound effects, sound output by a computer program with a voice interface, sounds played from a sound or music library or database, or sound from all of these sources or other sources.

[068] The person can wear various types of electronic devices that provide binaural sound. Examples of such electronic devices include, but are not limited to, earphones, headphones, electronic glasses, a head mounted display, a heads-up display, or another wearable electronic device (such as a device with two or more speakers). Furthermore, binaural sound can be provided to a person that does not wear earphones, such as providing binaural sound through two or more speakers.

[069] Block 210 states convolve the sound with a set of impulse responses or transfer functions for the person.

[070] Sound can be convolved either directly in the time domain with a finite impulse response (FIR) filter or with a Fast Fourier Transform (FFT). For example, an electronic device convolves the sound with a set of HRTFs, HRIRs, BRIRs, or RIRs and provides the person with binaural sound.

[071] In an example embodiment, convolution involves an audio input signal and an impulse response. The input signal can be a limited length audio signal (such as a pre-recorded digital audio file) or an ongoing audio signal (such as sound from a microphone or streaming audio over the Internet from a continuous source). The impulse response can be a set of HRIRs, BRIRs, RIRs, etc.

[072] Convolution applies one or more FIR filters to the input signals and convolves them into binaural audio output or binaural stereo tracks, such as convolving the input signal

into binaural audio output that is specific or individualized for the listener based on one or more of the listener's impulse responses.

[073] The FIR filters are derived binaural impulse responses that are obtained from example embodiments discussed herein (e.g., derived from signals received through microphones placed in, at, or near the left and right ear channel entrance of the person). Alternatively or additionally, the FIR filters are obtained from another source, such as generated from a computer simulation or estimation, generated from a dummy head, retrieved from storage, etc. Further, convolution of an input signal into binaural output can include sound with one or more of reverberation, single echoes, frequency coloring, and spatial impression.

[074] Processing of the sound can also include calculating and/or adjusting an interaural time difference (ITD), an interaural level difference (ILD), and other aspects of the sound in order to alter the cues and artificially alter the point of localization. Consider an example in which the ITD is calculated for a location (θ, ϕ) with the time-domain DTFs calculated for the left and right ears per the equations above. The ITD is located at the point for which the function attains its maximum value, known as the argument of the maximum or $\arg \max$ as follows:

$$\text{ITD} = \arg \max(\tau) \sum_n d_{l,\theta,\phi}(n) \cdot d_{r,\theta,\phi}(n + \tau).$$

[075] Subsequent sounds are filtered with the left HRTF, right HRTF, and ITD so that the sound localizes at (r, θ, ϕ) . Such sounds include filtering stereo and monaural sound to localize at (r, θ, ϕ) . For example, given an input signal as a monaural sound signal $s(n)$, this sound is convolved to appear at (θ, ϕ) when the left ear is presented with:

$$s_l(n) = s(n - \text{ITD}) \cdot d_{l,\theta,\phi}(n);$$

and the right ear is presented with:

$$s_r(n) = s(n) \cdot d_{r,\theta,\phi}(n).$$

[076] Block 220 states provide, through the earphones worn by the person, binaural sound such that the binaural sound localizes to the person at a sound localization point that is away from but proximate to the person.

[077] After the input signal is convolved, it can be provided to the person (listener), stored, transmitted, further processed, etc. Although some example embodiments teach that the sound is provided through earphones, binaural sound can also be provided to a person through two or more loudspeakers, such as through stereo speakers positioned in a room with listener or through car speakers.

[078] Consider an example in which a dedicated digital signal processor (DSP) executes frequency domain processing to generate real-time convolution of monophonic sound to binaural sound.

[079] By way of example, a continuous audio input signal $x(t)$ is convolved with a linear filter of an impulse response $h(t)$ to generate an output signal $y(t)$ as follows:

$$y(\tau) = x(\tau) \cdot h(\tau) = \int_{-\infty}^{\infty} x(\tau - t) \cdot h(t) \cdot dt.$$

[080] This reduces to a summation when the impulse response has a given length N and the input signal and the impulse response are sampled at $t = iDt$ as follows:

$$y(i) = \sum_{j=0}^{N-1} x(i - j) \cdot h(j).$$

[081] Execution time of convolution further reduces with a Fast Fourier Transform (FFT) algorithm and/or Inverse Fast Fourier Transform (IFFT) algorithm.

[082] Consider another example of binaural synthesis in which recorded or synthesized sound is filtered with a binaural impulse response (e.g., HRIR or BRIR) to generate a binaural output sound to the person. The input sound is preprocessed to generate left and right audio streams that are mapped to one or more virtual sound sources or sound localization points (known as SLPs). These streams are convolved with a binaural impulse response for the left ear and the right ear to generate the left and right binaural output sound signal. The output sound signal can be further processed depending on its final destination, such as applying a cross-talk cancellation algorithm to the output sound signal when it will be provided through loudspeakers or applying artificial binaural reverberation to provide 3D spatial context to the sound.

[083] One problem is that a distance from the source of the sound (e.g., the speaker in a HPED) and the recording location, (e.g., the head of the person wearing microphones in both ears) can impact the quality of impulse responses captured and subsequently used to convolve sound for the listener. For example, if this distance is too close (e.g., under one meter), then near-field HRTFs will be captured. When the distance is greater than about one meter, then far-field HRTFs will be captured. If this far-field distance is too far, however, the arriving sound signal may be too weak to effectively capture impulse responses at the head of the listener. Additionally, the sound arriving at the microphones may be overly affected with sound reverberations from the room or location where the recordings occur. Further, a person attempting to capture impulse responses to generate binaural sound may be unable to designate or measure optimal locations or distances for placing the HPED with respect to the head of the person.

[084] Example embodiments, including Figure 3 and other figures, address these problems and others.

[085] Figure 3 is a method to capture impulse responses when an HPED is within a

certain distance of a person.

[086] Block 300 states determine a distance from a HPED to a face of a person when the HPED is away from but proximate to the person.

[087] A determination is made of the distance between the HPED and the face of the person in order to know the distance when the HPED generates the sound to capture the impulse responses. By way of example, the HPED or another electronic device can determine this distance with various apparatus and methods that include, but are not limited to, a camera (such as measuring distance based on one or more pictures or video), a light emitter and sensor (such as a laser or infrared emitter and detector), ultrasonic range finder, and a proximity sensor. Alternatively, the distance can be measured (such as measured with a tape measure). As another example, the distance can be measured or approximated with a device, such as attaching the HPED to a pole, monopod, tripod, rod, or selfie-stick that has a known length and/or height.

[088] Block 310 makes a determination as to whether the distance is within a range to capture impulse responses of the person.

[089] The range depends on various factors, such as a quality of sound generated from or triggered by the HPED, the quality and type of microphones used, an amount of ambient noise present, an amount of reverberation or attenuation, a type of room, a type of communication for which the impulse responses will be used, and the type of impulse responses that a user or electronic device desires to capture.

[090] For near-field impulse responses, the range is from 0.0 meters to about 1.0 meter. For far-field impulse responses, the range is from about 1.0 meter to about 2.5 meters. These values are exemplary since the ranges can be further divided. For example, the far-field range can be shortened or lengthened depending on a type of sound being captured, reverberation at the location, an amount of reverberation desired, a type of communication for which the impulse response will be used, and other factors.

[091] As noted, one factor is the type of communication for which the impulse response will be used. For example, if an impulse response is being captured for voice telephony, the user may desire to have such impulse responses captured within a specific or predetermined range, such as 1.0 – 1.5 meters. As another example, if the impulse response is being captured for an advertisement, then the listener may not want the advertisement to localize close to the head of the listener. As such, the range for advertisements can be farther, such as 1.5 – 2.0 meters. As yet another example, a listener may want voices of an intelligent user agent (IUA) or an intelligent personal assistant (IPA) to localize relatively closer to his or her head. As such, the range for these voices can be relatively closer, such as 0.5 – 1.1 meters.

[092] If the answer to this determination is “no” then flow proceeds to block 320 that states take action.

[093] An action occurs when the distance is not within a specified or predetermined range. For example, the distance is not in an optimal range to generate useful impulse responses.

[094] Example actions include, but are not limited to, providing the user or other person with an audible warning (e.g., playing a sound warning from the HPED), providing the user or other person with a visual warning (e.g., displaying a visual indication on the HPED or other display, such as a text or light or an image), preventing the HPED from generating the sound to capture the impulse response (e.g., the HPED will not automatically generate the sound), allowing the HPED to generate the sound (e.g., the HPED generates the sound but notes a warning or designation with the distance), instructing the user or other person to change the distance (e.g., providing a written message or announcement from a voice to move closer or farther away in order to be within the range), capturing multiple impulse responses from the same location or other locations proximate to the location (e.g., capturing more impulse responses when the listener is not within a range), processing the impulse responses to compensate for the

distance, or taking another action.

[095] If the answer to the determination in block 310 is “yes” then flow proceeds to block 330 that states generate a sound from the HPED to create the impulse responses of the person.

[096] The HPED generates a sound so the microphones can capture an impulse response that is used to convolve sound for the listener. The HPED can also trigger or cause another device to generate a sound. For example, the HPED communicates with another HPED or speakers proximate to the person with the microphones, and this communication causes the other speakers to generate a sound to capture an impulse response. For example, the HPED instructs a stereo system to generate the sound through stereo speakers in a home theater system, or through a Bluetooth speaker mounted on a hand-held pole or another location around the listener such as a table.

[097] Block 340 states generate the impulse responses and/or transfer functions of the person based on the sounds captured in the left and right microphones of the person.

[098] The microphones capture the sounds at the left and right ears, and these sounds generate the set of HRTFs, HRIRs, RIRs, and/or BRIRs for the location of the HPED relative to the person. Subsequent sounds that are convolved with this set of impulse responses or transfer functions will localize to the listener at the position of the HPED when the HPED generated the sound for the impulse responses.

[099] The sounds captured at the microphones can be further processed to generate specific impulse responses or transfer functions. For example, the sounds are processed to remove CTFs, such as those associated with the earphones or those associated with an arm of a person (e.g., in a situation in which a person holds the HPED away from his or her face and generates the sound). The sounds can also be processed to remove impulse responses associated with the room in which the listener and HPED are located (such as removing RIRs from the impulse responses to generate HRIRs).

[0100] Block 350 states store the distance when the HPED generates the sound.

[0101] The distance between the HPED (or sound generating device) and the listening person wearing the microphones is recorded, stored, transmitted, processed, etc. For example, each set of impulse responses (i.e., one for the left ear and one for the right ear) has an associated distance from the listening person.

[0102] Block 360 states determine and store a location of the HPED and/or the person when the HPED generates the sound.

[0103] A record is created or updated that contains the SLP that localizes sound for the listener at the point where the sound was emitted. The record also contains the associated impulse responses and transfer functions, an identifier of the user whose head responses were measured, details of the capture process and context, and other information, such as other information discussed herein.

[0104] A HPED or other electronic device can determine its location with various apparatus and methods that include, but are not limited to, Global Positioning System or GPS (including assisted and synthetic GPS), cellular identification, WiFi (including received signal strength indication and wireless fingerprinting), internal sensors (including a compass, a magnetometer, an accelerometer, a gyroscope, or other inertial sensors), an ultrasonic or short-range wireless systems (including radio-frequency identification or RFID, near-field communication or NFC, broadcasting and reception of ultrasonic tones, Bluetooth beacons, and local transmitters (including transmitters mounted on buildings)), a camera (including a camera in a HPED), and combinations of these methods and apparatus.

[0105] The location and orientation of the HPED (or sound generating device) and the listening person wearing the microphones are recorded, stored, transmitted, processed, etc. For example, each set of impulse responses (i.e., one for the left ear and one for the

right ear) has one or more associated locations (such as having a location for the listening person and/or a location for the HPED or sound generating electronic device).

[0106] The distance, the location, and the orientation are stored for each impulse response. For example, this information includes (r, θ, ϕ) . This location can also include a GPS location or other location information that identifies where the HPED and/or listening person were when the impulse responses were generated and recorded.

[0107] If the impulse responses are not recorded in an anechoic chamber or special sound room or location, then each location is unique and will include room impulse responses (RIRs). As such, the sound recorded with the microphones can be processed to include BRIRs since the impulse responses include both HRIRs of the person and RIRs of the surrounding environment.

[0108] Locations are unique and so are the BRIRs captured for each person at each different location. An electronic device stores these locations and the associated impulse responses so desired impulse responses can be subsequently retrieved for use at the same location, for use in a similar location, or for use according to the wish of the user without regard to his location.

[0109] Consider an example in which a person desires to localize voice telephony to a location three feet from his head at either forty-five degrees to his right or forty-five degrees to his left. One SLP is (3.0 feet, $+45^\circ$, 0°) and is stored as SLP1; and another SLP is (3.0 feet, -45° , 0°) and is stored as SLP2. The person captures BRIRs at three different environmental locations for these two SLPs. These environmental locations include BRIRs captured at his office (stored as "Office"), BRIRs captured at his house (stored as "House"), and BRIRs captured at the park (stored as "Park"). The person further designates individuals stored in his electronic contact list to both a SLP and an environmental location. For example, the person designates his co-worker Alice as Office SLP1, and designates his wife as House SLP2. When Alice calls, her voice localizes at (3.0 feet, $+45^\circ$, 0°) with reverberations from the office. In other words, her voice sounds

like she is at the office. When his wife calls, her voice localizes at (3.0 feet, - 45°, 0°) with reverberations from their home. In other words, her voice sounds like she is at the house.

[0110] Traditionally, impulse responses were captured in a strictly controlled environment in which microphones were placed in ears of a real person or a dummy-head while the person or dummy-head was placed in an anechoic chamber and surrounded by many speakers. The distances between the speakers and person were known, and the azimuth and elevation angles from the face of the person or recording point to the speakers were also known. In this manner, HRTFs could be captured for precise locations around the head of the person or dummy.

[0111] One problem is the general public, however, does not have convenient or easy access to an anechoic chamber or controlled sound environment with expensive sound equipment.

[0112] Example embodiments, including Figure 4 and other figures, solve this and other technical problems associated with generating, capturing, and determining individualized impulse responses for people. Example embodiments capture impulse responses without this type of controlled or expensive environment. Instead, people can capture their individualized HRTFs, HRIRs, and/or BRIRs without relying on the expensive and time-consuming traditional practice of capturing impulse responses in an anechoic chamber or other specialized sound location.

[0113] Figure 4 is a method to determine a facial orientation of a listening person when an audio impulse response is recorded.

[0114] When an impulse response is captured and recorded at microphones located in the ears of the listening person, a facial orientation or head orientation of the person is determined and recorded. This facial or head orientation can include one or more of an azimuth angle of the face, an elevation angle of the face, a tilt of the face, a general location of the direction of gaze with respect to another object (such as a HPED), and a

facial expression or emotion of the face. By way of example, a facial or head orientation can be measured and recorded with respect to yaw, pitch, and roll of the head of the person. As another example, facial orientation can be measured, described, and/or stored with respect to a HPED. For instance, the HPED is located on a right side or left side of a face of a person, and the facial orientation is determined with respect to this location of the HPED.

[0115] Block 400 states determine a facial orientation of a person with respect to a HPED when the HPED is away from but proximate to the person.

[0116] Two factors determine a gaze of a person: a head or facial orientation (i.e., face pose or face direction) and eye orientation (i.e., eye gaze direction). Typically, the facial orientation determines a global direction of the gaze, and the eye orientation determines a local direction of the gaze. When a head of the person is level and he or she looks straight ahead, then the line-of-sight of the eye gaze and the facial orientation are straight ahead with 0° azimuth and 0° elevation and 0° tilt. This head position can also be described as a neutral head orientation position or neutral facial orientation with an X-Y-Z coordinate system or yaw, pitch, and roll to be $(0^\circ, 0^\circ, 0^\circ)$.

[0117] Various methods and/or apparatus can measure, determine, or estimate a deviation or variance from this neutral facial orientation and/or obtain one or more measurements of the yaw, pitch, and roll of the head or azimuth and elevation angles. One example embodiment uses facial recognition to determine or estimate a facial or head orientation of the person from one or more images or video captured with a camera in the HPED. The facial orientation can be described or recorded with respect to a location of the HPED that is generating the sound for the impulse responses.

[0118] One way to determine facial orientation is with a video-based facial orientation determination. This includes head-based approaches, ocular-based approaches (or eye-based approaches), and combinations of these two approaches.

[0119] Another way to determine facial orientation is with a classification-based facial orientation determination. This determines a relationship between face pose and its appearance via a statistical learning algorithm. Facial orientation is determined from face samples and various factors, such as illumination, pose variation, expression, etc.

[0120] Another way to determine facial orientation is with a geometry-based facial orientation determination. This builds a three-dimensional (3D) model of the face to determine facial orientation. For instance, facial contour and facial components of the person are matched with their projection on a 2D image.

[0121] Facial orientation can be determined from the relative position of salient anatomical local facial features of the person (such as a relative position of the nose, eyes, lips, and ears of the person). For example, the face is partitioned into several regions by detecting pixels that correspond to one or more salient facial features, facial components, or facial regions. Facial orientation is estimated from the relative positions of the salient regions.

[0122] Consider an example in which the HPED includes or communicates with a real-time facial orientation determiner, such as a real-time face interpretation engine for smartphones. This determiner estimates facial orientation or head poses (e.g., pitch, roll, and yaw) from facial images captured with the camera in the smartphone and from one or more motion sensors in the smartphone. For instance, an accelerometer and gyroscope in the smartphone detect tilt and motion of the smartphone, and the camera captures images or video of the person. Readings from the accelerometer and gyroscope provide information with regard to the direction of gravity and an intensity of the motion of the smartphone. As such, the smartphone is not required to be held in a particular orientation to determine the facial orientation of the person at whom the camera is directed. By way of example, an AdaBoost object detection algorithm detects a location of the face on the display of the smartphone. A spatial relationship between feature points or edges or corners of these feature points on the face (or landmarks) provides an estimation of facial orientation of the person.

[0123] Consider an example in which a camera in a HPED (such as a smartphone) captures an image of the person, and facial recognition software determines 2D feature points on the image and reconstructs a 3D pose. An algorithm (such as Pose from Orthography and Scaling with Iterations or POSIT) estimates the facial orientation of the person.

[0124] Consider an example in which a facial interpretation engine that executes on a smartphone estimates or determines facial orientation of a person.

[0125] Facial orientation can be determined with or without the use of a camera or image of the person. For example, the sound generated from the HPED and provided to the microphones positioned in the ears of the person provides information as to the facial orientation of the person. When the HPED is positioned directly in front of the face of the person, the ITD between the left and the right ear is zero. The ITD between the two ears, however, changes in a predictable or known amount as the azimuth angle increases or decreases. A measurement of the ITD thus correlates to a facial orientation of the person.

[0126] Facial orientation can also be determined with a compass. For example, the HPED includes a compass that measures and records a direction of a forward-looking direction of the face. Thereafter, the azimuth angle is calculated from compass directions of the HPED as it points toward and moves around a head of the person. Consider an example in which the person looks north at a compass heading of 0° . The HPED is positioned 1.0 meter from the face of the person and the camera lens of the HPED points at the head to a direction of south or 180° . Here, the HPED is directly in front of the person at an azimuth of 0° . The HPED then moves along an arc (i.e., maintaining its distance of 1.0 meter) until its compass points to South West or 225° while continuing to point the lens to the head of the person. The azimuth angle with respect to the person is calculated by subtracting the current compass direction of 225° from 180° to yield 45° , which corresponds to the facial orientation of the person with respect to the current location of the HPED.

[0127] A person can also determine or assist in determining facial orientation. For example, an HPED instructs a person to position the HPED approximately three to four feet from the face of the person at an azimuth angle of about 20° – 45° . When the person confirms the designated placement, the HPED generates the sound to capture the impulse responses in the microphones located in the ears of the person. This location where the sound was generated relative to the face of the person represents a SLP (i.e., a point or area where sound is localized). Thereafter, the HPED convolves sound so it localizes to this relative location for the person. The HPED can also use a timer or time delay feature to allow a person to return to his designated position prior to the sound being emitted.

[0128] Facial orientation and/or the location of the HPED can be based on a reference point, such as a point in a spherical coordinate system, a point in the X-Y-Z coordinate system, or another point. For example, a smartphone captures an image of a person while the smartphone is located one meter away from the face of the person and at a left side of the person. The smartphone determines the facial orientation to be looking to the right with respect to the location of the smartphone, and records its location as being away from the face and on its left side. An example embodiment can use a combination of two or more of these methods for a higher probability of accuracy.

[0129] Block 410 makes a determination as to whether the facial orientation is correct.

[0130] If the answer to this determination is “no” then flow proceeds to block 420 that states take an action.

[0131] An action occurs when the facial orientation is not correct or not preferred. For example, the person may be facing or looking in the wrong direction. As another example, the HPED or speaker of the HPED may be facing or pointing in a wrong direction. As yet another example, a SLP for the current facial orientation is already captured. As another example, the facial orientation may be correct, but the HPED is too close to the person, too far away from the person, or at an incorrect elevation angle with respect to the

person.

[0132] Example actions include, but are not limited to, providing the user or other person with a sound warning (e.g., playing a sound warning from the HPED), providing the user or other person with a visual warning (e.g., displaying a visual indication on the HPED, such as a text or light or an image), preventing the HPED from generating the sound to capture the impulse response (e.g., the HPED will not automatically generate the sound), allowing the HPED to generate the sound (e.g., the HPED generates the sound but notes a warning or designation with the facial orientation), instructing the user or other person to change the facial orientation or the orientation of the HPED (e.g., providing a written message or announcement from a voice to move or rotate the HPED and/or change a head orientation of the person), capturing multiple impulse responses from the same location or other locations proximate to the location (e.g., capturing more impulse responses when the listener and/or HPED does not have a specified or correct orientation), processing the impulse responses to compensate for the facial orientation, or taking another action.

[0133] If the answer to this determination is “yes” then flow proceeds to block 430 that states generate a sound from the HPED to capture audio impulse responses of the person.

[0134] The HPED generates the sound, and the microphones at the ears of the listener capture the impulse responses at the listener.

[0135] Correct facial orientation can depend on one or more factors including, but not limited to, current settings of the HPED, preferences of the person, desired locations for SLPs, previous SLP or impulse responses captured, environmental conditions, accuracy of determining or estimating impulse responses, a location of the HPED with respect to the face of the person, a location of the person and/or HPED, a level or amount of background noise, an orientation or rotation of the HPED with respect to the head orientation of the person, what sound is selected to generate the impulse responses, a

distance between the face of the person and the HPED, an intended use for the impulse responses (e.g., used to localize sound in gaming applications, telephony applications, intelligent user agent or intelligent personal assistant applications, etc.), physical attributes of the listening person (such as his or her age, size, hair, amount of face exposed, amount of ears exposed, etc.), and other factors.

[0136] Further, the facial orientation can be calculated and stored with specific coordinates or locations (such as a specific azimuth and/or elevation angle), and/or other coordinates (such as an (x, y, z) position and orientation (yaw, pitch, roll) in the room), and/or with general coordinates or locations (such as located at a right side of a face, located at a left side of a face, located above a head of the person, etc.).

[0137] Block 440 states store the facial orientation of the person and/or the orientation of the HPED when the HPED generates the sound.

[0138] In addition to storing an orientation of the face and/or HPED, other information can be determined and stored as well. By way of example, this other information includes, but is not limited to, a height of the HPED from ground, altitude above sea level, a height of a face of the person from ground, objects recognized between the person and the HPED, objects proximate to the person, a room scan and the positions of the HPED and listener within the room, a distance between the HPED and the face of the person, a time of day and calendar date, a location of the HPED and/or person when the impulse responses are captured, a decibel level of the sound generated from the HPED, a type of sound used or selected to generate the impulse responses, a number of impulse responses generated and captured, ambient sound or background at the location of the HPED and/or person when the impulse responses are captured, environmental conditions (such as temperature, humidity, etc.) when the impulse responses are generated and captured, and other data discussed herein.

[0139] Consider an example in which a smartphone executes an application that assists a user (Alice) in automatically obtaining impulse responses so she can enjoy localized

voices for voice telephony. Alice desires to localize voices for calls in one of three locations or at one of three SLPs: SLP 1 defined as stereo sound (where voices appear to originate inside her head), SLP 2 defined as approximately three feet from a right side of her face at an azimuth angle of about 20° to 45° and an elevation angle of about 0° , and SLP 3 defined as approximately three feet from a left side of her face at an azimuth angle of about negative 20° to negative 45° and an elevation angle of about 0° . **Bob (Alice's friend) holds her smartphone and views its display that shows him where to position the smartphone with respect to Alice's face. Bob moves about four feet from Alice and holds her smartphone out in front of himself so the speaker is pointed at her face. The smartphone determines it is located three feet and five inches from Alice's face, and this position is correct since it is within an acceptable range for localizing voice calls. The smartphone also determines that it is located at an azimuth angle of $+28^\circ$ and at an elevation angle of 3° from Alice's face. These angles are within an acceptable range to position an SLP for voice calls. Upon arriving at this position, the smartphone instructs by announcing: "Taking picture in three, two, one." One second later a speaker in the smartphone generates a distinct tone that is specific for generating audio impulse responses that can be used to convolve sound. Microphones in Alice's ears capture this tone, and the smartphone generates BRIRs for the current location and stores them as SLP 2. The smartphone instructs Bob to move to the left side of Alice so it can generate another tone and capture Alice's BRIRs for SLP 3. Thereafter, when Alice receives a voice call, her smartphone convolves the sound according to the measured impulse responses so the voice of the caller localizes to one of SLP 2 or SLP 3.**

[0140] Alternatively Alice's smartphone can work in cooperation with Bob's smartphone to direct Bob to hold it at the designated position and generate the audio impulse from Bob's smartphone or from Bob himself.

[0141] In another example embodiment, the HPED does not produce the audio impulse itself at a designated instant but instead instructs the user to cause the audio impulse to be emitted. For example, the HPED enters a mode of readiness to capture the audio impulse and the HPED informs the user to cause the audio impulse within twenty

seconds. The user can cause a sound that the HPED will recognize by prearrangement as the target impulse. The target impulse is the designated sound that the HPED will analyze in order to create the BRIRs and HRTFs. As an alternative example, the HPED informs the user that it is in the ready state for the next twenty seconds and directs the user to cause the audio impulse. The HPED then analyzes the impulses and selects the target impulse that is suitable to use in the creation of a set of BRIRs and/or HRTFs. As another example, the HPED can be set in a ready mode to capture target impulses that occur in a prearranged zone such as an approximate azimuth angle or with an approximate ITD. Further, the HPED can be designated in its ready mode to analyze the first impulse following a certain spoken trigger word or sound, or following a voice signal that exceeds a certain volume, such as double the average volume of the background noise. The examples above illustrate that an example embodiment can capture and record the sounds at a location for various lengths of time and then select the optimal impulse to use in creating the BRIRs and HRTFs. The HPED can also be instructed to disregard impulses according to a set of criteria, and/or to consider for analysis impulses that match a set of criteria and disregard ones that do not match the criteria.

[0142] In another example embodiment, the HPED can use the set(s) of criteria in order to select the target impulse, however the HPED is not commanded to enter a ready state. Instead, an application executing on the HPED continually or periodically captures, records, and erases sound from the environment. Memory retains a certain number of seconds of the recorded sound prior to any moment in a dynamic cache. The application continuously monitors the cache and analyzes the recorded sound to identify one or more keywords or key sounds. The keywords or key sounds can be the target impulse(s), or they can indicate that the target impulse is following or has preceded the keyword or key sound. Upon the identification of a target impulse, the application stores the impulse to memory and thereafter processes saved impulses into BRIRs and/or HRTFs and enters them in the SLP database. Consider an example in which the following sounds are designated as target impulses: the sound of a rubber band snapping against a book, the sound of the soles of two shoes clapped together, the sound of an isolated hand clap, the sound of a tongue click, the sound of a wine glass clink, the sound of a car key rap on a

glass pane.

[0143] Consider an example in which Alice and two friends are seated in a restaurant. Alice wishes to create a designated SLP for each of them. Alice says, "I have a new binaural phone. Please clap yourselves in." Her phone is in the ready state to capture predefined target impulses, she is wearing her microphones at her ears, and keeps her head facing forward. Bob then claps his hands once and says, "I'm Bob." Yoko says, "This is Yoko," and claps. During this period the application identifies two separate target impulses and saves each one to memory for subsequent processing into SLPs. The SLPs are added to the database and associated with Bob and Yoko in her smartphone's contact list. Thereafter during phone calls with Bob and/or Yoko she can localize each to their relative position to her when they were at the restaurant.

[0144] When an impulse response is captured in accordance with an example embodiment, a SLP is calculated for the impulse response and its corresponding location, such as the (r, θ, ϕ) location where the HPED was when it generated the sound. Each SLP has unique characteristics since each SLP can be captured at a different location (r, θ, ϕ) , captured with a different head orientation of the listener, captured with a different sound, captured with a different speaker generating the sound, captured under different environmental conditions, etc. If the user has one or two SLPs, then these SLPs and their characteristics can be readily remembered or managed. As the number of SLPs increases, however, it becomes more difficult for the user to manage the SLPs and determine information such as which SLP corresponds to which location, what SLPs the user has, what areas near the user do not have SLPs, what RIRs or HRIRs are associated with which SLPs, how accurate a particular SLP is, which SLPs a user prefers for use with particular headphones, which SLPs a user prefers for speaking with particular people, which SLPs a user prefers at particular times of day or under particular circumstances, where sound for each SLP actually localizes to the user, etc. Example embodiments assist in solving these and other technical problems.

[0145] Figure 5 is a method to designate one or more SLPs to a zone or area around a

head of a person. This method assists the person in managing his or her SLPs.

[0146] Block 500 states divide an area around a head of a person into a plurality of three-dimensional (3D) zones.

[0147] Areas around the head of the person are divided into a plurality of different zones. The zones can have similar, same, or different sizes and shapes that include regular or irregular 3D shapes including, but not limited to, one or more of a sphere, a cube, a cuboid, a cone (including truncated cones), arc, a cylinder, a pyramid (including a square-based pyramid), a tetrahedron, a triangular prism, polyhedrons, uniform 3D shapes, hemisphere, a partial sphere, a portion or slice of a sphere, non-uniform or irregular 3D shapes, and other shapes.

[0148] Consider an example in which the head of the person is centered at an origin (0, 0, 0) of an X-Y-Z coordinate system or spherical coordinate system. An imaginary sphere of radius (r) encircles the head with the head at the origin. This sphere is further divided into areas, pieces, or zones. For example, the sphere is cut or divided into a plurality of horizontal cross sections, vertical cross-sections, cones, or other 3D shapes. Each zone represents a location where one or more SLPs can be derived or exist.

[0149] The following illustrates an example to define an area above a head of the person whose head is centered at the imaginary sphere. Consider an example in which an imaginary horizontal plane cuts through this sphere above the head of the person such that a spherical cap defines an area above this horizontal plane. This spherical cap can be further divided into zones by cutting the spherical cap with imaginary horizontal, vertical, or angled planes. One or more SLPs can be designated into each zone. Alternatively, a zone can be designated with no SLPs.

[0150] Block 510 makes a determination as to whether the HPED is located in one of the zones.

[0151] For example, when the head of the person is positioned at an origin (0, 0, 0) of the coordinate system, then the location of the HPED can be calculated with respect to this position. For instance, its location (r, θ , ϕ) or (x, y, z) with respect to the face of the person (i.e., the origin) can be calculated as discussed herein. The location is then compared with the coordinates of the zones to determine into which zone the HPED currently resides.

[0152] The HPED can actually have multiple location designations. One designation is its location in space relative to the head of the person, such as designating the location of the HPED at (r, θ , ϕ) or (x, y, z). Another designation is its GPS or physical location, such as 22° 33' and 114° 14'. **Another designation is a name of a physical location, such as an address, name of a building, name of a room, etc.** Another designation is a name or designation of a zone or area around the head of the person, such as an area around the head of the person having ten zones and the HPED being located in Zone 3.

[0153] An example embodiment compares a current location of the HPED with respect to the locations of the zones around the head of the person. This comparison reveals in which zone the HPED is currently located.

[0154] A determination as to whether the HPED is located in a zone and an identification of that zone depends on a number of factors, such as the number of zones, the size of the zones, the shape of the zones, the distance between the HPED and the person, etc.

[0155] Consider an example in which a head of the person is a center of sphere that is divided into multiple segments or zones. One of these zones (designated as Zone A) exists as a top portion of this sphere formed from a horizontal plane that dissects the sphere above the head of the person (previously provided as an example of a spherical cap in the discussion of block 500). If the sphere has a radius (R), and Zone A has a height (h) and its own base radius (r), then the volume of Zone A (i.e., the spherical cap) is given by the following equation:

$$V (\text{Zone A}) = 1/6 \cdot \pi \cdot h \cdot (3r^2 + h^2).$$

Using the Pythagorean theorem ($A^2 + B^2 = C^2$), results in the following equation:

$$(R - h)^2 + r^2 = R^2.$$

Solving for the base radius (r), yields:

$$r = (h(2R - h))^{1/2}.$$

[0156] The angle (α) between the normal to the sphere at the bottom of the spherical cap and the base plane can be calculated with the following equation:

$$R - h = R \sin \alpha,$$

$$\alpha = \sin^{-1}((R - h)/R).$$

Further, a geometric centroid (z) of the spherical cap (i.e., Zone A) occurs per the following equation:

$$z = (3(2R - h)^2)/(4(3R - h)).$$

[0157] These equations, along with the location of the HPED at (r, θ , ϕ) or (x, y, z), determine whether the HPED is located in the spherical cap, Zone A.

[0158] Of course, these equations represent an example of how geometry and coordinates can be used to determine whether the HPED is within a particular zone around the user. Other equations and computations can be used and depend on the size, shape, and locations of the zones and HPED. Furthermore, other methods can be used to determine in which the zone the HPED is located.

[0159] If the answer to this determination is “no” then flow proceeds to block 520 that states take an action.

[0160] An action occurs when the HPED is not within a zone. For example, the HPED may be too far away from the person or may be too close to the person. As another example, the HPED may be located in an area that does not include a zone, such as being under the person or in a pocket of the person. Further, a zone may already have a sufficient number of effective SLPs.

[0161] Example actions include, but are not limited to, providing the user or other person with a sound warning (e.g., playing a sound warning from the HPED), providing the user or other person with a visual warning (e.g., displaying a visual indication on the HPED, such as a text or light or an image), displaying a visual indication of the zone or zones so the user can move to or navigate to the zone and correct location, providing verbal instructions that indicate where the user should physically move so the user and/or HPED is within a particular zone, preventing the HPED from generating the sound to capture the impulse response (e.g., the HPED will not automatically generate the sound), allowing the HPED to generate the sound (e.g., the HPED generates the sound but notes a warning or designation with the facial orientation), instructing the user or other person to change the facial orientation or the orientation of the HPED (e.g., providing a written message or announcement from a voice to move or rotate the HPED and/or change a head orientation of the person), capturing multiple impulse responses from the same location or other locations proximate to the location (e.g., capturing more impulse responses when the listener and/or HPED does not have a specified or correct orientation), processing the impulse responses to compensate for the facial orientation, or taking another action.

[0162] If the answer to this determination is “yes” then flow proceeds to block 530 that states generate a sound from the HPED to capture impulse responses for the person.

[0163] The HPED generates the sound to capture the impulse responses at the

microphones located in the ear of the listener.

[0164] Block 540 states designate the zone as including a sound localization point (SLP) for the person to localize binaural sound.

[0165] A record of information is kept with respect to each zone. This information includes, but is not limited to, one or more of a location of a zone, a size and shape of a zone, a creation date and time of a zone, a number of SLPs in the zone, a location of each SLP in the zone (e.g., in what part of the zone is the SLP located), a number of times and duration of time a zone or SLP in the zone is used to localize sound, which sounds and sound types localize to which SLPs, an effectiveness or accuracy of a user to localize sound to the SLP in a zone, voices or people or contacts designated to a SLP, names of each zone and each SLP, and other information discussed herein.

[0166] Block 550 states store the information for the zones and the SLPs.

[0167] This information includes information discussed herein with respect to the zones and the SLPs.

[0168] The zones and SLPs can also be mapped to provide a user with a 2D or 3D visual indication of the zones and a location of the SLPs in the zones. For example, the HPED displays an image of the zones and where the SLPs are located in each zone. The image can also include other information, such as names, types, color descriptors, and other portions of the information.

[0169] Impulse responses can be particular to a location or type of location when the impulse responses include noise reverberations, such as noise reverberations caused from a size of the location, a shape of the location, objects at the location, environmental conditions at the location, etc. These impulse responses occur in the form of RIRs that are included in the BRIRs captured at the microphones of the ears of the listener when the HPED generates the sound. RIRs can also be added to or removed from the sound

after the impulse responses are recorded, such as adding a high-ceiling effect so the sounds appear to originate in a cathedral.

[0170] Problems can exist when a user has many different stored impulse responses for different occasions, different locations, different purposes, etc. and it can be difficult to manage these various impulse response sets or transfer functions associated with the impulse responses. For instance, a user could have a series of SLPs for voice calls, and each of these SLPs can have a different BRIR. Some SLPs provide the listener with a sound effect so that a voice of the speaker appears to originate at the beach, at an office, at a home, or at another location. Further, the user could have designated or captured some SLPs at his house and captured others at his office. Each SLP can have a set of rules to determine when it should be activated to localize a sound.

[0171] Example embodiments, including those discussed in Figures 6 and 7, address these technical problems and others discussed herein.

[0172] Figure 6 is a method to map a SLP to a location.

[0173] Block 600 states generate a sound from a HPED to capture impulse responses of a person wearing microphones when the HPED is proximate to but away from the person.

[0174] The HPED generates a sound or causes another electronic device to generate a sound that is used to capture impulse responses at microphones located in, at, or near the ears of the person.

[0175] Block 610 states store a location of the person and/or the HPED when the HPED generates the sound.

[0176] A location of the HPED and/or person is stored and can be retrieved, processed, transmitted, etc. The information stored is not limited to location, but also includes a facial or head orientation of the person, coordinate information regarding the person and/or

HPED (including (r, θ, ϕ) or (x, y, z) discussed herein), an address of the person and/or HPED when the impulse response was generated, a description or an identification of the location (such as labeling the location according to room type, like “bedroom” or “office”), and other information discussed herein.

[0177] Block 620 states generate a SLP at the location of the HPED when the HPED generated the sound for the impulse responses.

[0178] When sound is subsequently convolved with the impulse responses for this location, the sound will appear to originate relative to the listener at the location of the HPED at the instant in time when the HPED generated the sound. Example embodiments set or establish a SLP for this location.

[0179] Further, a SLP can be provided with a descriptive name so a user can recognize the SLP and/or its location. For instance, a user captures an impulse response in her bedroom when her HPED is four feet from her face. The location of the HPED represents **where she wants to localize her husband’s voice when he calls her. A SLP designates to this location and is stored as “Telephony Husband” so she can distinguish this SLP from other SLPs that are designated to her.**

[0180] Block 630 states store the location and other information.

[0181] The information is stored in the HPED and/or stored in another location, such as stored on a server, another electronic device, a database, memory, a cloud, etc.

[0182] Block 640 states provide the SLP to a map for subsequent retrieval.

[0183] In addition to storing the information, it can be provided to the person in a visual and/or audio context. An example embodiment maps the SLP and other information into a 2D or 3D map so the person can easily and quickly see the SLP and relevant information associated with it. The SLP and accompanying information can be retrieved and viewed

on or through a display, such as being viewed on an electronic device (such as a computer or television), a HPED, electronic glasses, a head-up display or other display adapted for virtual reality (VR) or augmented reality (AR), or other type of wearable electronic device.

[0184] Consider an example in which Alice wears earphones with microphones and uses her HPED to capture numerous BRIRs in different rooms while in her house. A SLP designates for each BRIR. An example embodiment builds or retrieves a 3D interactive map of her house and places each SLP at its corresponding location in the map. Alice displays the map on her HPED and sees where each SLP is located. Further, the HPED knows the location of each SLP in order to select or recommend a SLP for Alice, such as an intelligent personal assistant recommending or selecting a SLP for Alice.

[0185] Figure 7 is a method to select a SLP for a person and convolve sound to localize at the SLP.

[0186] Block 700 states determine a location of a person.

[0187] Example methods to locate a person include, but are not limited to, tracking a person and/or HPED with GPS, tracking a smartphone with its mobile phone number, tracking a HPED via a wireless router or wireless network connection to which the HPED communicates for Internet access, tracking a person and/or HPED with a tag or barcode, tracking a person and/or HPED with a radio frequency identification (RFID) tag and reader, tracking a location of a person with a camera (such as a camera in conjunction with facial recognition), and tracking a location of a person with a sensor. Alternatively, a person can provide his or her location (such as speaking a location to an intelligent personal assistant that executes on a HPED).

[0188] Consider an example in which a smartphone executes an application that tracks and shares its current location in real-time with other applications, electronic devices, and/or example embodiments discussed herein.

[0189] Block 710 makes a determination as to whether one or more SLPs exist for the location.

[0190] SLPs can be stored or associated with locations, including zones, areas, places, rooms, etc. When a person goes to or near a location, then the SLPs associated with this location are retrieved. For example, a HPED of a person compares its current location with the locations of SLPs stored for the person to determine whether one or more SLPs exist for the location.

[0191] The determination as to whether a SLP exists for a particular location can be based on one or more factors. These factors can determine how or which SLPs are selected.

[0192] For example, one factor is proximity of the person and/or HPED to the SLP or location where the impulse responses associated with the SLP were generated. A SLP can be selected based on its proximity to the person and/or HPED. For instance a SLP closest to the person and/or HPED is selected.

[0193] Another factor is the RIR associated with the SLP. For example, a closest SLP may not be appropriate if this SLP has an RIR that is not associated with the current location of the person. Consider an example in which Alice has many SLPs throughout her house. Each SLP includes RIRs for the particular room in which the SLP is located. SLPs in the bathroom are convolved with bathroom RIRs; SLPs in the bedroom are convolved with bedroom RIRs; etc. When Alice receives a call, the voice of the caller is convolved with a RIR corresponding to the location of Alice. While standing in the hallway, Alice receives a call from Bob on her smartphone. The closest SLP is a bathroom BRIR that is located a few feet from Alice. Since Alice is not in the bathroom, her smartphone selects a bedroom BRIR since the HPED senses her walking direction and predicts she will enter this room shortly and not the bathroom.

[0194] Another factor is historic usage or personal preferences. When the person was previously at this location, he or she localized sound with a particular SLP and BRIR, and this SLP and BRIR are recommended for this location based on the past selection. For example, a user has a favorite SLP to use for voice calls, or has a specific SLP used for calls with a particular friend regardless of their location at the time of a call.

[0195] If the answer to this determination is “no” then flow proceeds to block 720 that states take an action.

[0196] An action occurs when a SLP or impulse response does not exist for the current location of the person. For example, the person enters a room or location for the first time, and no RIRs or BRIRs exist for this location.

[0197] Example actions include, but are not limited to, choosing a generic impulse response in order to convolve the sound (e.g., choosing a BRIR taken from or associated with another physical location); choosing a RIR or BRIR not particular to the location but associated with the location (e.g., when the person is in a car for which no RIR exists, then choosing a RIR from another car); instructing the user to capture a BRIR for this location; playing a particular ringtone that signifies to the user that a SLP or impulse response is not available for the current location; selecting to localize the sound at a predetermined location with no RIR information (e.g., localize the sound with individualized HRTFs of the user that do not include RIRs); providing the user or other person with a sound warning , providing the user or other person with a visual warning , denying the HPED from localizing sound (e.g., providing the sound in stereo or mono to the person instead of providing binaural sound that localizes to an external location); instructing the user or other person to move to another location where a SLP or impulse response was previously captured for the person; or taking another action (such as an action discussed herein).

[0198] If the answer to this determination is “yes” then flow proceeds to block 740 that states select a SLP to localize the sound to the person.

[0199] An electronic device chooses one or more available SLPs and their associated impulse responses or transfer functions to convolve sound so the sound localizes to the selected SLP.

[0200] Block 750 states convolve the sound with the set of impulse responses or transfer functions associated with the selected SLP so the sound localizes to the SLP that is proximate but away from the person. Sound is convolved so it localizes to the person at the SLP.

[0201] Voice telephony is more realistic when the voices are localized to include RIRs for the current location of the listener. One problem is that the electronic device of the listener may not have RIRs for his current location and hence cannot convolve sounds with impulse responses from the location.

[0202] Figure 8 and other example embodiments address this problem and others.

[0203] Figure 8 is a method to retrieve RIRs and convolve sound based on a location of a person.

[0204] Block 800 states determine a location of a person. The location of the person can be determined as described in connection with block 700 or other blocks discussed herein.

[0205] Block 810 makes a determination as to whether a RIR exists for the location.

[0206] RIRs can be stored and associated with locations. When a person goes to or near a location, then the RIRs associated with this location or location type are retrieved. For example, a HPED of a person compares its current location with the locations of stored RIRs available locally and online and determines whether one or more RIRs exist for the location or are suitable for the location.

[0207] In one example embodiment, the HPED or other electronic device of the person captures the RIRs for the location. For example, while the person is at the location, a HPED of the person generates a sound, and electronic microphones capture impulse responses for the sound. In another example embodiment, the HPED or other electronic device retrieves RIRs for the location. For instance, RIRs are stored in a database or memory for various locations around the world, and these RIRs are available for retrieval. These RIRs can be actual ones captured at the location or computer generated or estimated RIRs for the location. As yet another example, the HPED or electronic device retrieves RIRs for a similar location. For instance, if the location is a church but no RIRs exist for this particular church, then RIRs for another church are retrieved. Physical attributes of the location (such as size, shape, and other physical qualities) can be used to more closely match RIRs from other locations.

[0208] In example embodiments, reverberation can be physically measured or digitally simulated. For example, to apply a reverberation effect, an incoming audio signal is convolved with an impulse response. Convolution multiplies the incoming audio signal with samples in the impulse response file. Various impulse responses for specific locations (ranging from small rooms to large areas) can be retrieved from memory and then used in convolution reverb applications to provide an audio signal with acoustic characteristics that are particular to the specific location.

[0209] Consider an example in which a transfer function or frequency response for an area (such as a room or other location) is measured with a sound that covers the frequency spectrum. For instance, a white noise excites the area, and the noise is recorded at locations near the source and another location in space. Coefficients of an impulse response are generated as an inverse Fourier Transform.

[0210] Consider an example of convolution reverb in which one or more microphones are placed in a room and a brief pulse sound is generated. The microphones capture both the original sound and the response or reverberations from the room to generate RIRs for the

room.

[0211] If the answer to this determination is “no” then flow proceeds to block 820 that states take an action.

[0212] An action occurs when an RIR or impulse response does not exist for the current location of the person. For example, the person enters a room or location for the first time, and no RIRs or BRIRs exist for this location.

[0213] Example actions include those discussed in connection with block 730 and/or taking another action (such as an action discussed herein).

[0214] If the answer to this determination is “yes” then flow proceeds to block 830 that states convolve sound with the RIR.

[0215] Block 840 states provide the convolved sound to the person.

[0216] For example, an electronic device convolves the sound and provides it to the person through speakers, such as speakers in earphones, wearable electronic device, or loud speakers.

[0217] Consider several examples in which Alice prefers to localize voices on phone calls with RIRs captured from the physical location where she is talking to increase realism. This preference is set on her smartphone.

[0218] Alice receives a VoIP call from Bob while she is at her grandmother's house. Her smartphone determines that Alice has not previously received a call at this location and hence is unable to retrieve either a RIR or BRIR for her current location. In response to this determination, the smartphone rings with a distinctive tone, and Alice recognizes this tone and its implication that no RIRs or BRIRs are available for her location. This distinctive tone is actually the sound used to capture impulse responses. While her

smartphone is ringing and generating this distinctive tone, Alice holds the smartphone in her hand with her arm stretched out away from her face. Microphones in her earphones record the tones, and her smartphone immediately generates BRIRs for Alice. When the smartphone captures sufficient impulse response from a designated location, it stops generating the tones, answers the call, and convolves the incoming voice with the BRIRs that it just obtained while Alice was answering the phone call.

[0219] Consider the example above in which Alice is at her grandmother's house when she receives a voice call but her smartphone does not have RIRs or BRIRs for her location. Alice answers the call and talks with a headset that includes microphones and speakers. A voice of the caller localizes to a SLP that is proximate to Alice with her HRTFs, but the voice is not convolved with RIRs because they do not exist for her current location. During the call, Alice asks Bob to generate a RIR reference impulse. Bob walks several feet away from Alice and activates his phone to generate a distinctive tone. The microphones in Alice's ears recognize the tone as one to generate impulse responses for her current location. Based on these impulse responses, her smartphone generates BRIRs particular to Alice and her location and then determines the RIRs for the room using the new BRIR and her known HRTF. Alice continues the conversation with convolution now including the room's RIR, and without changing her SLP.

[0220] Consider the example above in which Alice is at her grandmother's house when she receives a call but her smartphone does not have RIRs or BRIRs for her location. Her smartphone determines that Alice has not previously received a call at this location and rings with a distinctive tone. This tone, however, is not the tone to capture the impulse responses for Alice and the room. Instead, the tone alerts Alice that such impulse responses are missing or that she is missing individualized HRIRs for her location. Alice moves the smartphone to a location proximate to her face to where she would like to localize the voice of the caller. The smartphone continues to ring, but tracks its location. When the smartphone moves to the correct location (e.g., to a particular zone prearranged by Alice or to a location to measure a far-field HRTF), or when Alice indicates the location is correct, the smartphone generates a specific tone designed to

capture audio impulse responses, such as generating a frequency-swept sine wave or other sound. Based on these impulse responses, her smartphone generates BRIRs particular to Alice and her location. Alice answers the call, and her smartphone convolves the caller's voice with the newly captured BRIRs and localizes it to a SLP that is away from but proximate to Alice.

[0221] Figures 9A – 9D show a person 900 standing next to a table 902 and capturing audio impulse responses with microphones 910A and 910B in his left and right ears. The person 900 holds a hand held portable electronic device (HPED) 920 in his hand 930 with his left arm 940 straight and extended away from his body.

[0222] When the left hand 930 is located away from the face of the person 900 with the arm in an outstretched position, the HPED 920 (such as a smartphone) generates a specific sound or tone to generate audio impulse responses at the microphones 910A and 910B. The HPED 920 or another electronic device processes the impulse response to generate HRIRs, BRIRs, RIRs, and/or HRTFs that are used to convolve sound to the person.

[0223] When sound is subsequently convolved with the impulse responses or transfer functions, the sound localizes for the person 900 to the location where the HPED 920 was when it generated the sound or tone. These locations are stored as sound localization points or SLPs.

[0224] Figures 9A – 9D show a plurality of SLPs 950 formed around the person 900. Each SLP represents a location where the person generated a sound or tone with the HPED 920 and captured the impulse response with the microphones 910A and 910B located in his ears. By way of example, the figures show the person 900 activating the HPED 920 to generate a sound or tone at SLP 952. The HPED 920 or another electronic device (such as a cloud server) stores the locations of the SLPs and other information associated with them.

[0225] As shown in Figures 9A – 9D, the SLPs 950 form a pattern (such as a partial sphere) around the head or body of the person 900. A first set of SLPs 954 form a partial sphere around a left side of the person, and a second set of SLPs 956 form a partial sphere around a right side of the person. SLPs 954 were generated when the HPED 920 was extended outwardly in the left hand 930 of the person 900, and SLPs 956 were generated when the HPED 920 was extended outwardly in the right hand of the person 900. A length of each arm serves as a radius for the partial spheres.

[0226] Figures 9A – 9D show the SLPs formed around the person in a structured pattern. The SLPs, however, can occur at various locations, such as arbitrary locations where the person places the HPED and generates the tone to capture the impulse responses with the microphones.

[0227] Example embodiments enable the person to select locations for where to generate the SLPs. The person can select not only where to position a SLP but also how many SLPs to generate and/or store. For example, one person may want to generate one or two SLPs for localizing sound, while another person may want to generate hundreds of SLPs for localizing sound from one or more distances.

[0228] Example embodiments are not limited to capturing impulse responses and generating SLPs while a HPED is being held in a hand of a person. People have significant flexibility in deciding where to place a SLP such as deciding distances and angles of a location, and one or more of (r, θ, ϕ) . This flexibility further includes allowing people to place SLPs at, on, or near objects, such as placing their HPED on an object and generating the sound from this location. Figures 10 – 12 illustrate some additional examples of these flexibilities.

[0229] Figures 10A – 10D show a person 1000 standing and capturing audio impulse responses with microphones 1010A and 1010B in his left and right ears. The person 1000 holds a pole, rod, or selfie-stick 1020 that attaches or connects to a HPED 1030. A plurality of SLPs 1040 encircles or surrounds the person 1000.

[0230] When the HPED 1030 is connected to one end of the pole 1020, the person 1000 can position the HPED at a much farther distance from his face than if he were holding the HPED in his hand and extending his arm. In this manner, the person can generate and capture far-field HRTFs since the combined length of his arm and the selfie-stick is greater than about 1.0 meter. Depending on the length of a person's arm and a length of the pole, the person can generate and capture impulse responses from 1.0 – 2.0 meters or more from his ears. For example, a person could generate sounds with a smartphone positioned about three feet to about eight feet from the face of the person. The pole thus ensures that the person generates and captures far-field audio impulse responses and provides more flexibility to generate SLPs in a number of locations.

[0231] Figures 10A – 10B show an example configuration of SLPs 1040 that were captured with left and right arms of a person 1000. A right hemisphere of SLPs 1050 forms on a right side of the person, and a left hemisphere of SLPs 1052 forms on a left side of the person.

[0232] As noted, a spherical configuration of SLPs is an example shape since the person can place SLPs at a variety of different locations according to his or her desires. SLPs are not restricted or confined to a particular distance or configuration around the person. Instead, locations and numbers of the SLPs are user-selected. This is contrary to traditional systems (such as an anechoic chamber) in which the number and location of the speakers (which coincide to the SLPs) were fixed and not user-selected.

[0233] Figure 11 shows a person 1100 sitting at a table 1102 and capturing audio impulse responses with microphones 1110A and 1110B in his left and right ears. While a HPED 1120 sits on the table 1102, the HPED generates a tone or sound that the microphones capture as the impulse responses. The location of the HPED when it generates the sound represents the SLP to where subsequent sound is convolved and localized for the person.

[0234] Figure 11 shows two SLPs 1130 and 1132 that were previously generated when

the HPED was at the respective locations. For instance, when the HPED was placed next to the lamp 1140, the HPED activated the sound to generate the impulse response, and the SLP 1132 was subsequently created for that location. Likewise, when the HPED as placed next to the computer 1150, the HPED activated the sound to generate the impulse response, and the SLP 1130 was created for that location. The HPED is currently resting next to some books 1160 and is ready to generate another SLP for the person.

[0235] Figure 11 shows that a person is not required to hold the HPED when generating the tone and capturing the impulse responses. Instead, the HPED is set or placed at a location, and it generates the tone from this location. This embodiment provides the person with much flexibility in determining where to generate a SLP. The person in Figure 11, for example, can generate SLPs on his table and position these SLPs at locations convenient or desirable to him. For example, the person 1100 can designate the SLP 1132 as a **“virtual right speaker”** and a SLP created from an impulse response at the HPED 1120 as a **“virtual left speaker.”** Figure 12 shows a person 1200 sitting in an automobile 1210 and capturing audio impulse responses with microphones 1220A and 1220B in his left and right ears while holding a HPED 1230 in his right hand 1240. The left hand 1250 remains on the steering wheel 1260 of the automobile as the person continues to drive and look straight ahead toward the road.

[0236] The HPED 1230 generates a specific sound or tone used to generate audio impulse responses that can be used to create localized sound at a SLP. In this instance, the SLP is located to a right side of the person and at a passenger seat 1270 of the automobile. Subsequent sounds (including voices) can be localized to this SLP at the passenger seat 1270. For example, the person can communicate with an intelligent user agent or autopilot whose voice localizes to the SLP at the passenger seat or **communicate with another person during a phone call with the other person’s voice** localizing to the passenger seat 1270.

[0237] Example embodiments enable users to generate SLPs at locations specified or desired by the users. Furthermore, these SLPs can be close to the person (such as near-

field locations) or farther from the person (such as far-field locations). Further yet, users can generate a SLP and immediately begin to localize sound to this location. For example, once the microphones detect the impulse responses, the HPED processes them to derive transfer functions. The HPED then convolves sound input signals with the transfer functions so the sound localizes to the location or origin of the sound (i.e., where the HPED or other sound source was physically located when it generated the sound for the impulse responses).

[0238] Figure 13 shows a person 1300 sitting in a chair 1310 at a table 1320 and being surrounded by a plurality of SLPs 1330 illustrated as square blocks that are located away from but proximate to his face. The person 1300 holds a HPED 1340 in his left hand 1350 and points the HPED at one of the SLPs, shown as SLP 1360. Pointing the HPED at the SLP in effect selects this SLP for sound localization for a source he designates. Thereafter, sounds will localize to this selected SLP, such as sounds heard through a wearable electronic device 1370. The wearable electronic device also displays the SLPs 1330 to the person.

[0239] SLP 1360 is darkened when compared to the other SLPs 1330 to visually distinguish it from the other SLPs as being the one selected for sound localization. By way of example, SLP 1360 can be distinguished with shading, light, color, indicia, symbols, text, or other visually recognizable forms to signify its selection and to distinguish it from non-selected SLPs. Further, the SLPs 1330 are viewable on or through a display, such as a display of the HPED 1340, wearable electronic glasses, or another electronic device.

[0240] Consider an example of a phone call that originates from Bob to Alice, both of whom subscribe to a single channel monophonic mobile phone cellular network. They both have smartphones with stereo capability to play music, and they both have stereo earphones to listen to the music and to take telephone calls. Bob originates the call to **Alice with the smartphone's stock phone application and waits while he hears the ring indicator.** Alice is driving her car wearing headphones and is listening to her phone

playing music when she hears a ringtone. The ringtone indicates the she does not have an SLP configured for her current location on the road. She also has not yet taken a call using a SLP with her new phone application that supports binaural speech convolution. She is already wearing her headphones with microphones so she takes this opportunity to create a SLP suitable to use in the car so she can enjoy a more natural phone conversation with the perception of Bob's voice externalized. On the display of her phone there is an "answer phone" button/option and a button/option that says, "answer at new SLP." Alice selects the latter option to answer at a new SLP. Her phone indicates that it will generate an SLP when the phone is steady at arm's length. Bob is then connected and they exchange greetings. Soon Alice tells Bob, "Hold on for a moment, I'm in a car and I'd like to externalize you..." She extends her right arm toward the passenger seat while keeping her face safely toward the road. The phone's binaural calling application monitors the image received by the phone's camera. When the application detects Alice's facial profile in the center of the image, the application uses the image to calculate the phone's location relative to the face of Alice and determines the distance to her face to be arm's length. The phone further uses its motion detector to determine that it is steady and provides an indication (e.g., vibratory or audio) to Alice that it is ready to create the SLP.

[0241] Alice's phone then emits a short tone repeatedly and captures the audio impulse responses with the microphones in Alice's ears as she faces the road. The application then creates a SLP and a new SLP record in memory and stores a timestamp, the new transfer function, the captured photo of Alice's profile, the GPS location at the time of the tone capture, and the position of the phone at the time of tone. The phone also recognizes the brand and model of Alice's headphones so it creates an additional common transfer function (CTF) and stores the CTF as well as the model of the headphones with the SLP record.

[0242] The sound from Bob's call is optimized for speech by his phone's hardware and signal processing that has removed noise and non-speech from the sound. Alice's application convolves the sound to localize at the SLP while the call conversation

continues.

[0243] When Alice receives subsequent voice calls, her intelligent user agent (IUA) selects the transfer function that pre-calculates allowance for her headphones if she is wearing them at that time.

[0244] **Bob is not using a phone application that can convolve Alice's monophonic voice,** so he hears her voice internalized (i.e., inside his head). Later Alice uses the same phone to place a call to Bob from her home while she sits at her kitchen table and wears headphones. Her phone checks her GPS location and finds a SLP record that corresponds to Bob and her location at the kitchen table. A binaural phone application executing in her phone selects this SLP to convolve the call with Bob. When Alice places the call to Bob, she hears the ring localize to the SLP that is away from but proximate to her. This external localization notifies her that this location will be used as the SLP for **Bob's voice when he answers. When Bob answers, Alice hears him speak from across the kitchen table at the SLP.**

[0245] After their telephone conversation finishes, Bob downloads a call convolving application to his smartphone. Later, Alice calls Bob while he is at a café. Bob has not prepared a SLP and is unsure how to create one. During the phone call, he asks Alice to help him establish a SLP. Alice says, "I'm here at my kitchen table. Since you are at the café, I will send you my SLP. It might not fit great but it'll probably work." Alice tells Bob she will reveal her SLP location so he can see it. She allows permission for the other party, Bob, to see the relative positions of herself and where she has positioned the SLP of Bob. Bob can see an illustration on his phone of the relative positions of Alice and the SLP of his voice. He sees that Alice is about three feet away and a little to his right. Alice instructs him to select, "Enforce congruence" and he does.

[0246] In order to make the call congruent, Bob's IUA searches his SLP database for an SLP that can convolve Alice's voice to a zone about three feet away from him and a little to his right (which corresponds to Alice's position relative to him). Bob's SLP database,

however, has no such SLP or available record, so his IUA requests a congruent SLP from Alice's call convolving application. In response to this request, Alice's call convolving application sends Bob's call convolving application the transfer function she is using (without her headphone CTF response modification). Bob's call convolving application uses the transfer function received from Alice, but swaps the left and right channels. This swapping happens in real-time when Bob selects "Enforce congruence" on his phone, and suddenly the voice of Alice moves from inside his to an external localization point a few feet in front of him slightly to the right. Bob talks to Alice with her voice localized across from him at the café table.

[0247] Later during their phone call, Alice moves to her bedroom and reclines on the bed with her face toward the ceiling. She still perceives his voice about three feet in front of her between her face and the ceiling rendered in an acoustic environment of her kitchen. Both of these audio attributes are irritating to Alice, so she issues a command to her phone to scan for an alternate SLP. An intelligent personal assistant (IPA) in her phone suggests several different SLPs from her database. Her IPA briefly convolves Bob's voice to each of the SLPs so Alice can hear the effects. Alice provides a verbal command to her IPA to select one of the alternate SLPs. The newly selected SLP suits her because as she lies on her back looking at the ceiling, she can hear Bob from beside her on the bed, facing her. This newly selected SLP also provides a cozy, attenuating, audio environment that gives her conversation with Bob a more intimate setting.

[0248] After the conversation Bob says goodnight and terminates the call. Alice hears a designated call termination sound that allows her to confirm that Bob is disconnected and not just pausing. The call termination sound begins at the SLP and transforms into a non-localized sound that is internalized by Alice, reminiscent of how monaural calls terminate from inside the head.

[0249] Consider an example of a Voice-over Internet Protocol (VoIP) call originating from Bob to Alice over a Transmission Control Protocol/Internet Protocol (TCP/IP) network. They both have smartphones with stereo capability to play music, and they both have

stereo earphones to listen to music and to take telephone calls. Their earphones include binaural microphones. Bob originates the call to Alice with a Session Initiation Protocol (SIP) client that can transmit two full-duplex channels, sending the input from microphones at the earphones he is wearing, and receiving the left and right channels of the other party at his left and right ears. He initiates the VoIP call to Alice by selecting her phone number from the directory displayed in a SIP client application. This application initiates the call by first logging into a designated telephony switch that supports SIP connections and also makes available a stereo or binaural codec.

[0250] Bob is at his house holding a birthday party for Alice with some of her friends. Alice, however, cannot come to the party. Alice enjoys hearing the binaural sound **captured at Bob's ears and streamed to her through the stereo codec without alteration.** As he walks around the room talking with her friends, Alice can localize the different voices at the party. Bob is her audio avatar during the call.

[0251] While the party is going on, Alice is in a noisy hotel lobby and Bob is not interested in experiencing the localization of the sounds in her physical environment. Instead, Bob prefers to hear her speech without other noise so he can speak with her. So he gives a command to his smartphone that causes it to use a signal processing unit to dynamically separate her sound signals and to remove all sound except the sound of her speech. The smartphone also moves the sound of her speech to an SLP positioned directly to his left, with the angle of projection of her voice being directly forward, parallel to the direction of the projection of his own voice. Sound localization with this orientation gives Bob a familiar spatial configuration in which Alice accompanies him on his left, pacing him, and strolling with him around the room at the party.

[0252] To accomplish this localization, Bob first creates a SLP to his left by issuing to his **smartphone the voice command, "Move voice."** This command triggers the smartphone to go into tone capture mode to generate a new SLP. He would like to place the SLP one meter away, which is longer than his arm, so he asks a friend to position his phone one meter to his left. A sound convolving application that executes in his smartphone creates

a sound and proceeds to transform the impulse responses into a transfer function and generate a new SLP that corresponds to the location one meter to his left. A moment later the SLP is created and the sound convolving application determines that the single voice being received by the phone is the desired source to play at the new SLP. Suddenly, Bob hears Alice speaking at his side, facing the same direction that he faces. He walks through the party with his invisible friend, the guest of honor, Alice, whom only he can hear.

[0253] Figure 14 is a computer system or electronic system 1400 that includes a handheld portable electronic device or HPED 1402, a computer or electronic device (such as a server) 1404, electronic earphones 1406, and storage or memory 1408 in communication with each other over one or more networks 1410.

[0254] The handheld portable electronic device 1402 includes one or more components of computer readable medium (CRM) or memory 1420, a display 1422, a processing unit 1424, one or more interfaces 1426 (such as a network interface, a graphical user interface, a natural language user interface, a natural user interface, a reality user interface, a kinetic user interface, touchless user interface, an augmented reality user interface, and/or an interface that combines reality and virtuality), a camera 1428, one or more sensors 1430 (such as micro-electro-mechanical systems sensor, a biometric sensor, an optical sensor, radio-frequency identification sensor, a global positioning satellite (GPS) sensor, a solid state compass, gyroscope, magnetometer, and/or an accelerometer), a sound localization system 1432 (such as a system that localizes sound, adjusts sound, predicts or extrapolates characteristics of sound, detects specific audio impulse responses, and/or executes one or more methods discussed herein), an audio impulse response signal or sound generator 1434, a facial orientation system and/or facial recognition system 1436, a head/eye tracker 1438, a location determiner 1440 (such as hardware and/or software discussed herein to determine or track location), microphones 1442, speakers 1444, and a battery or power supply 1446.

[0255] The storage 1408 can include memory or databases that store one or more of

SLPs (including their locations and other information associated with a SLP including rich media such as sound files and images), user profiles and/or user preferences (such as user preferences for SLP locations and sound localization preferences), impulse responses and transfer functions (such as HRTFs, HRIRs, BRIRs, and RIRs), and other information discussed herein.

[0256] The network 1410 can include one or more of the Internet, a local area network (LAN), a wide area network (WAN), a metropolitan area network (MAN), a personal area network (PAN), home area network (HAM), and other public and/or private networks. Additionally, the electronic devices do not have to communicate with each other through a network. As one example, electronic devices can couple together via one or more wires, such as a direct wired-connection. As another example, electronic devices can communicate directly through a wireless protocol, such as Bluetooth, near field communication (NFC), or other wireless communication protocol. One device can trigger another device using sound waves.

[0257] The sensors 1430 can further include motion detectors (such as sensors that detect motion with one or more of infrared, optics, radio frequency energy, sound, vibration, and magnetism).

[0258] By way of example, a location determiner or location tracker includes, but is not limited to, a wireless electromagnetic motion tracker, a system using active markers or passive markers, a markerless motion capture system, video tracking (e.g. using a camera), a laser, an inertial motion capture system and/or inertial sensors, facial motion capture, a radio frequency system, an infrared motion capture system, an optical motion tracking system, an electronic tagging system, a GPS tracking system, an object recognition system (such as using edge detection), and other embodiments, such as hardware and/or software discussed in connection with block 360 and other example embodiments.

[0259] The sound localization system 1432 performs various tasks with regard to

managing, generating, retrieving, storing, and selecting SLPs. These tasks include generating audio impulse responses or transfer functions for a person, convolving sound per the impulse responses or transfer functions, dividing an area around a head of a person into zones or areas, determining what SLPs are in a zone or area, mapping SLP locations and information for subsequent retrieval and display, selecting SLPs when a user is at a determined location, and executing one or more other blocks discussed herein. The sound localization system can also include a sound convolving application that convolves sound according to one or more audio impulse responses and/or transfer functions.

[0260] The audio impulse response signal generator or sound generator 1434 generates a sound, tone, or signal that produces the audio impulse response captured at the microphones (such as the microphones being worn by a person). By way of example, such sounds include, but are not limited to, a known spectrum stimulus sound, a frequency-swept sine wave, a click, a voice-like sound, a pulse, a maximum length sequence (MLS), a pseudo-random binary sequence, white or pink noise, a ping, a complementary Golay code, a voice announcing a word or a phrase, or another type of sound generated from a speaker to generate audio impulse responses. The sounds can be generated by the sound generator and can also be prepared sound files present on the HPED 1402 or received and updated from time to time through the network 1410.

[0261] The facial orientation system and/or facial recognition system 1436 recognizes faces of people, determines a facial orientation of a person, determines a distance from the HPED to a person, and performs other functions discussed herein with regard to facial orientation and facial recognition.

[0262] Electronic device 1404 includes one or more components of computer readable medium (CRM) or memory 1460, a display 1462, a processing unit 1464, one or more interfaces 1466, and a sound localization system 1472 (such as a system that performs one or more functions discussed herein).

[0263] The electronic earphones 1406 include one or more of microphones 1480 (such as left and right microphones that fit inside an ear of a person), speakers 1482 (such as a left and right speaker that are located in, at, or near an ear of a person), a battery or power supply 1484, and a wireless transmitter/receiver 1486. The wireless transmitter/receiver can support audio streams discussed herein (for example, 4 simultaneous streams, 2 channels out plus 2 channels in, at sample rates per by an example embodiment) as well as other data.

[0264] By way of example, a computer and an electronic device include, but are not limited to, handheld portable electronic devices (HPEDs), wearable electronic glasses, watches, wearable electronic devices, portable electronic devices, computing devices, electronic devices with cellular or mobile phone capabilities, digital cameras, desktop computers, servers, portable computers (such as tablet and notebook computers), electronic and computer game consoles, home entertainment systems, handheld audio playing devices (example, handheld devices for downloading and playing music and videos), personal digital assistants (PDAs), combinations of these devices, devices with a processor or processing unit and a memory, and other portable and non-portable electronic devices and systems.

[0265] The processor unit includes a processor (such as a central processing unit, CPU, microprocessor, application-specific integrated circuit (ASIC), etc.) for controlling the overall operation of memory (such as random access memory (RAM) for temporary data storage, read only memory (ROM) for permanent data storage, and firmware). The processing unit communicates with memory and performs operations and tasks that implement one or more blocks of the flow diagrams discussed herein. The memory, for example, stores applications, data, programs, algorithms (including software to implement or assist in implementing example embodiments) and other data.

[0266] Figure 15 is a computer system or electronic system 1500 that includes an electronic device 1502, a server 1504, a wearable electronic device 1508, earphones 1510, and speakers 1512 in communication with each other over one or more networks

1514.

[0267] By way of example, electronic devices include, but are not limited to, a computer, handheld portable electronic devices (HPEDs), wearable electronic glasses, watches, wearable electronic devices, portable electronic devices, computing devices, electronic devices with cellular or mobile phone capabilities, digital cameras, desktop computers, servers, portable computers (such as tablet and notebook computers), smartphones, electronic and computer game consoles, home entertainment systems, handheld audio playing devices (example, handheld devices for downloading and playing music and videos), appliances (including home appliances), personal digital assistants (PDAs), electronics and electronic systems in automobiles (including automobile control systems), combinations of these devices, devices with a processor or processing unit and a memory, and other portable and non-portable electronic devices and systems.

[0268] Electronic device 1502 includes one or more components of computer readable medium (CRM) or memory 1515, one or more displays 1522, a processor or processing unit 1524, one or more interfaces 1526 (such as a network interface, a graphical user interface, a natural language user interface, a natural user interface, a reality user interface, a kinetic user interface, touchless user interface, an augmented reality user interface, and/or an interface that combines reality and VR), a camera 1528, one or more sensors 1530 (such as micro-electro-mechanical systems sensor, an activity tracker, a pedometer, a piezoelectric sensor, a biometric sensor, an optical sensor, radio-frequency identification sensor, a global positioning satellite (GPS) sensor, a solid state compass, gyroscope, magnetometer, and/or an accelerometer), a location or motion tracker 1532, one or more speakers 1534, impulse responses, transfer functions, and/or SLPs 1536, a sound localization system 1538 (such as a system that executes one or more methods or blocks discussed herein), one or more microphones 1540, a predictor 1542, an intelligent user agent (IUA) and/or intelligent personal assistant (IPA) 1544, sound hardware 1546, and a user profile builder and/or user profile 1548.

[0269] Server 1504 includes computer readable medium (CRM) or memory 1550, a

processor or processing unit 1552, and an intelligent personal assistant 1554.

[0270] By way of example, the intelligent personal assistant or intelligent user agent is a software agent that performs tasks or services for a person, such as organizing and maintaining information (emails, calendar events, files, to-do items, etc.), responding to queries, performing specific one-time tasks (such as responding to a voice instruction), performing ongoing tasks (such as schedule management and personal health management), and providing recommendations. By way of example, these tasks or services can be based on one or more of user input, prediction, activity awareness, location awareness, an ability to access information (including user profile information and online information), user profile information, and other data or information.

[0271] Wearable electronic device 1508 includes computer readable medium (CRM) or memory 1570, one or more displays 1572, a processor or processing unit 1574, one or more interfaces 1576 (such as an interface discussed herein), a camera 1578, one or more sensors 1580 (such as a sensor discussed herein), a motion or location tracker 1582, one or more speakers 1584, one or more impulse responses, transfer functions, and SLPs 1586, a head tracking system or head tracker 1588, an imagery system 1590, a sound localization system 1592, and one or more microphones 1594.

[0272] The earphones 1510 include a left and a right speaker 1596 and a left and a right microphone 1598.

[0273] By way of example, the sound hardware 1546 includes a sound card and/or a sound chip. A sound card includes one or more of a digital-to-analog (DAC) converter, an analog-to-digital (ATD) converter, a line-in connector for an input signal from a sound source, a line-out connector, a hardware audio accelerator providing hardware polyphony, and a digital-signal-processor (DSP). A sound chip is an integrated circuit (also known as a "chip") that produces sound through digital, analog, or mixed-mode electronics and includes electronic devices such as one or more of an oscillator, envelope controller, sampler, filter, and amplifier.

[0274] By way of example, the imagery system 1590 includes, but is not limited to, one or more of an optical projection system, a virtual image display system, virtual augmented reality system, lenses, and/or a spatial augmented reality system. By way of example, the virtual augmented reality system uses one or more of image registration, computer vision, and/or video tracking to supplement and/or change real objects and/or a view of the physical, real world.

[0275] In some instances, a HPED may not have an internal speaker capable of generating a sound sufficient to capture impulse responses at the microphones. The HPED can communicate with a separate sound impulse generator (such as a separate speaker 1512 proximate to the HPED) and cause this impulse generator to emit the sound to generate the impulse responses at the microphones. For example, the sound impulse generator 1512 can be a speaker coupled with or in communication with the HPED and mounted together with the HPED. The HPED can trigger the sound impulse generator to make the sound. An orientation allows the location and direction of transmission of the sound generated to be similar or the same for both the HPED speaker and the sound impulse generator 1512.

[0276] The event predictor or predictor 1542 predicts or estimates events including, but not limited to, switching or changing between binaural and stereo sounds at a future time, changing or altering binaural sound (such as moving a SLP, reducing a number of SLPs, eliminating a SLP, adding a SLP, starting transmission or emission of binaural sound, stopping transmission or emission of binaural sound, etc.), predicting an action of a user, predicting a location of a user, predicting an event, predicting a desire or want of a user, predicting a query of user (such as a query to an intelligent personal assistant), etc. The predictor can also predict user actions or requests in the future (such as a likelihood that the user or electronic device requests a switch between binaural and stereo sounds or a change to binaural sound). For instance, determinations by a software application, an electronic device, and/or the user agent can be modeled as a prediction that the user will take an action and/or desire or benefit from a switch between binaural and stereo sounds

or a change to binaural sound (such as pausing binaural sound, muting binaural sound, reducing or eliminating one or more cues or spatializations or localizations of binaural sound). For example, an analysis of historic events, personal information, geographic location, and/or the user profile provides a probability and/or likelihood that the user will take an action (such as whether the user prefers binaural sound or stereo sound for a particular location, a particular listening experience, or a particular communication with another person or an intelligent personal assistant). By way of example, one or more predictive models are used to predict the probability that a user would take, determine, or desire the action.

[0277] The predictive models can use one or more classifiers to determine these probabilities. Example models and/or classifiers include, but are not limited to, a Naive Bayes classifier (including classifiers that apply Bayes' theorem), k-nearest neighbor algorithm (k-NN, including classifying objects based on a closeness to training examples in feature space), statistics (including the collection, organization, and analysis of data), collaborative filtering, support vector machine (SVM, including supervised learning models that analyze data and recognize patterns in data), data mining (including discovery of patterns in data-sets), artificial intelligence (including systems that use intelligent agents to perceive environments and take action based on the perceptions), machine learning (including systems that learn from data), pattern recognition (including classification, regression, sequence labeling, speech tagging, and parsing), knowledge discovery (including the creation and analysis of data from databases and unstructured data sources), logistic regression (including generation of predictions using continuous and/or discrete variables), group method of data handling (GMDH, including inductive algorithms that model multi-parameter data) and uplift modeling (including analyzing and modeling changes in probability due to an action).

[0278] Consider an example in which the predictor tracks and stores event data over a period of time, such as days, weeks, months, or years for users of binaural sound. This event data includes recording and analyzing patterns of actions with the binaural sound and motions of an electronic device (such as an HPED or electronic earphones). Based

on this historic information, the predictor predicts what action a particular user will take with an electronic device (e.g., whether the user will accept or place a voice call in binaural sound or stereo sound and with whom and at what time and locations, whether the user will communicate with an intelligent personal assistant in binaural sound or stereo sound at what times and locations and for what durations, whether the user will listen to music in binaural sound or stereo sound and from which sources, where the user will take the electronic device, in what orientation it will be carried, the travel time to the destination and the route to get there, in what direction a user will walk or turn or orient his/her head or gaze, what mood or emotion a user is experiencing, etc.).

[0279] One or more electronic devices can also monitor and collect data with respect to the person and/or electronic devices, such as electronic devices that the person interacts with and/or owns. By way of example, this data includes user behavior on an electronic device, installed client hardware, installed client software, locally stored client files, **information obtained or generated from the user's interaction with a network (such as web pages on the internet)**, email, peripheral devices, servers, other electronic devices, programs that are executing, SLP locations, SLP preferences, binaural sound preferences, music listening preferences, time of day and period of use, sensor readings (such as common gaze angles and patterns of gaze at certain locations such as a work desk or home armchair, common device orientations and cyclical patterns of orientation such as one gathered while a device is in a pocket or on a head), etc. The electronic devices collect user behavior on or with respect to an electronic device (such as the **user's computer**), **information about the user, information about the user's computer, and/or information about the computer's and/or user's interaction with the network.**

[0280] By way of example, a user agent (including an IUA) and/or user profile builder monitors user activities and collects information used to create a user profile, and this user profile includes public and private information. The profile builder monitors the user's interactions with one or more electronic devices, the user's interactions with other software applications executing on electronic devices, activities performed by the user on external or peripheral electronic devices, etc. The profile builder collects both content

information and context information for the monitored user activities and then stores this information. By way of further illustration, the content information includes contents of web pages and internet links accessed by the user, people called, subjects spoken of, locations called, questions or tasks asked of an IPA, graphical information, audio/video information, patterns in head tracking, device orientation, location, physical and virtual positions of conversations, searches or queries performed by the user, items purchased, likes/dislikes of the user, advertisements viewed or clicked, information on commercial or financial transactions, videos watched, music played, interactions between the user and a user interface (UI) of an electronic device, commands (such as voice and typed commands), information relating to SLPs and binaural sound, etc.

[0281] The user profile builder also gathers and stores information related to the context in which the user performed activities associated with an electronic device. By way of example, such context information includes, but is not limited to, an order, frequency, duration, and time of day in which the user accessed web pages, audio streams, SLPs, information regarding the user's response to interactive advertisements, calls, requests and notifications from intelligent personal assistants (IPAs), information as to when or where a user localized binaural sounds, switched to or from binaural sound sending or receiving, etc.

[0282] As previously stated, the user profile builder also collects content and context information associated with the user interactions with various different applications executing on one or more electronic devices. For example, the user profile builder monitors and gathers data on the user's interactions with a telephony application, an AAR application, web browser, an electronic mail (email) application, a word processor application, a spreadsheet application, a database application, a cloud software application, a sound localization system (SLS), and/or any other software application executing on an electronic device.

[0283] Consider an example in which a user agent and/or electronic device gathers SLP preferences while the user communicates during a voice exchange with an intelligent user

agent, an intelligent personal assistant, or another person during a communication over the Internet. For example, a facial and emotional recognition system determines facial and body gestures of a user while the user communicates during the voice exchange. For instance, this system can utilize Principal Component Analysis with Eigenfaces, Linear Discriminate Analysis, 3D facial imaging techniques, emotion classification algorithms, Bayesian Reasoning, Support Vector Machines, K-Nearest Neighbor, neural networks, or a Hidden Markov Model. A machine learning classifier can be used to recognize an emotion of the user.

[0284] By way of example, SLP preferences can include a person's personal likes and dislikes, opinions, traits, recommendations, priorities, tastes, subjective information, etc. with regard to SLPs and binaural sound. For instance, the preferences include a desired or preferred location for a SLP during a voice exchange, a desired or preferred time when to localize sound versus not localize sound, permissions that grant or deny people rights to localize to a SLP that is away from but proximate to a person during a voice exchange (such as a VoIP call), a size and/or shape of a SLP, a length of time that sound localizes to a SLP, a priority of a SLP, a number of SLPs that simultaneously localize to a person, etc. Consider an example in which a HPED has a mobile operating system that includes a computer program that is an intelligent personal assistant (IPA) and knowledge navigator. The IPA uses a natural language user interface to interact with a user, answer questions, perform services, make recommendations, and communicates with a database and web services to assist the user. The IPA further includes or communicates with a predictor and/or user profiler to provide its user with individualized searches and functions specific to and based on preferences of the user. A conversational interface (e.g., using a natural language interface with voice recognition), personal context awareness (e.g., using user profile data to adapt to individual preferences with personalized results), and service delegation (e.g., providing access to built-in applications in the HPED) enable the IPA to interact with its user and perform functions discussed herein. For example, the IPA predicts and/or intelligently performs generating and capturing the sound from a HPED to acquire the impulse responses and/or transfer functions or and executing other methods discussed herein.

[0285] Consider an example in which a HPED has a mobile operating system with a computer program that is an intelligent personal assistant (IPA) and knowledge navigator. The IPA uses a natural language user interface to interact with a user, answer questions, perform services, make recommendations, and communicate with a database and web services to assist the user. The IPA further includes or communicates with a predictor and/or user profile to provide its user with individualized searches and functions specific to and based on preferences of the user, such as selecting a SLP at a location. A conversational interface (e.g., using a natural language interface with voice recognition and machine learning), personal context awareness (e.g., using user profile data to adapt to individual preferences and provide personalized results), and service delegation (e.g., providing access to built-in applications in the HPED) enable the IPA to interact with its user and perform functions discussed herein (such as one or more blocks in the figures). For example, the IPA predicts and/or intelligently performs generating a tone for an impulse response, convolving sounds with specific impulse response or transfer functions, selecting between multiple SLPs at a location, and executing other methods discussed herein.

[0286] Figures 14 and 15 show example electronic devices with various components. One or more of these components can be distributed or included in various electronic devices, such as some components being included in an HPED, some components being included in a server, some components being included in storage accessible over the Internet, some components being in an imagery system, some components being in wearable electronic devices, and some components being in various different electronic devices that are spread across a network or a cloud, etc.

[0287] The speaker that generates the sound to capture the impulses responses can be physically separate from the HPED. By way of example, Figure 16 shows an electronic system 1600 in which a HPED 1601 and an impulse generator or speaker 1603 connect to an end of a pole, rod, selfie-stick, or monopod 1604. The HPED 1601 and the speaker 1603 are connected to or positioned between a back brace 1605 and a front brace 1606

such that the HPED and speaker are next to each other and pointing in a same or similar direction for generation and capture of audio impulse responses as discussed herein.

[0288] Example embodiments are not limited to using a HPED to generate a sound from its speaker to capture audio impulse responses since the HPED can execute one or more blocks discussed herein to manage HRTFs in other ways. For example, the HPED executes one or more blocks discussed herein and designates a location for a SLP, and retrieves HRTFs or HRIRs for the location of this SLP. For example, Alice holds the HPED in her hand away from her face and provides a command to the HPED to capture a SLP (e.g., Alice issues a voice command or taps on the display). In response to this command, the HPED determines its location with respect to the face or facial orientation of Alice and generates a SLP for this location (such as determining distance, azimuth angle and/or elevation angle). The HPED then retrieves an individualized HRTF for Alice from memory (such as an online database) and convolves sound with this HRTF so the sound localizes to the SLP that coincides with where the HPED was when Alice provided the command to the HPED. The HPED can select a set of HRTFs for this location of the SLP or another location near this SLP. For example, Alice holds the HPED at a location for a near-field HRTF, but the HPED retrieves a far-field HRTF corresponding to the azimuth and elevation angles of where the SLP was generated.

[0289] Blocks and/or methods discussed herein can be executed and/or made by a user, a user agent (including machine learning agents and intelligent user agents), a software application, an electronic device, a computer, firmware, hardware, a process, a computer system, and/or an intelligent personal assistant. Furthermore, blocks and/or methods discussed herein can be executed automatically with or without instruction from a user.

[0290] As used herein, **“impulse response”** is a reaction to an audio input signal in response to external change. Impulse responses include recordings of reverberation caused by an acoustic space (such as a room, human head and/or body, dummy head, etc.) when an impulse is played. The impulse response can be from physical objects or mathematical systems of equations describing or estimating the objects. Further, the

impulse can be modeled in either discrete time or continuous time. Furthermore, systems can use transfer functions or impulse response for analysis (the transfer function being a Laplace Transform of the impulse response). Examples of impulse responses include RIRs, HRIRs, and BRIRs.

[0291] **As used herein, “line-of-sight” is the forward-looking direction of the face of the person that extends along a straight line from an end of the nose of the person.**

[0292] **As used herein, a “user” can be a human being, an intelligent personal assistant (IPA), a user agent (including an intelligent user agent and a machine learning agent), a process, a computer system, a server, a software program, hardware, an avatar, or an electronic device. A user can also have a name, such as Alice, Bob, and Charlie, as described in some example embodiments.**

[0293] **As used herein, a “user agent” is software that acts on behalf of a user. User agents include, but are not limited to, one or more of intelligent user agents and/or intelligent electronic personal assistants (IPAs, software agents, and/or assistants that use learning, reasoning and/or artificial intelligence), multi-agent systems (plural agents that communicate with each other), mobile agents (agents that move execution to different processors), autonomous agents (agents that modify processes to achieve an objective), and distributed agents (agents that execute on physically distinct electronic devices).**

[0294] **As used herein, a “user profile” is personal data that represents an identity of a specific person or organization. The user profile includes information pertaining to the characteristics and/or preferences of the user. Examples of this information for a person include, but are not limited to, one or more of personal data of the user (such as age, gender, race, ethnicity, religion, hobbies, interests, income, employment, education, location, communication hardware and software used including peripheral devices such as head tracking systems, abilities, disabilities, biometric data, physical measurements of their body and environments, functions of physical data such as HRTFs, etc.),**

photographs (such as photos of the user, family, friends, and/or colleagues, their head and ears), videos (such as videos of the user, family, friends, and/or colleagues), and user-specific data that defines the user's interaction with and/or content on an electronic device (such as display settings, audio settings, application settings, network settings, stored files, downloads/uploads, browser and calling activity, software applications, user interface or GUI activities, and/or privileges).

[0295] Examples herein can take place in physical spaces, in computer rendered spaces (VR), in partially computer rendered spaces (AR), and in combinations thereof.

[0296] The processor unit includes a processor (such as a central processing unit, CPU, microprocessor, field programmable gate array (FPGA), application-specific integrated circuit (ASIC), etc.) for controlling the overall operation of memory (such as random access memory (RAM) for temporary data storage, read only memory (ROM) for permanent data storage, and firmware). The processing unit communicates with memory and performs operations and tasks that implement one or more blocks of the flow diagrams discussed herein. The memory, for example, stores applications, data, programs, algorithms (including software to implement or assist in implementing example embodiments) and other data.

[0297] Consider an example in which the SLS or portions of the SLS include an integrated circuit FPGA that is specifically customized, designed, configured, or wired to execute one or more blocks discussed herein. For example, the FPGA includes one or more programmable logic blocks that are wired together or configured to execute combinational functions for the SLS.

[0298] Consider an example in which the SLS or portions of the SLS include an integrated circuit or ASIC that is specifically customized, designed, or configured to execute one or more blocks discussed herein. For example, the ASIC has customized gate arrangements for the SLS. The ASIC can also include microprocessors and memory blocks (such as being a SoC (system-on-chip) designed with special functionality to execute functions of

the SLS).

[0299] Consider an example in which the SLS or portions of the SLS include one or more integrated circuits that are specifically customized, designed, or configured to execute one or more blocks discussed herein.

[0300] In some example embodiments, the methods illustrated herein and data and instructions associated therewith are stored in respective storage devices, which are implemented as computer-readable and/or machine-readable storage media, physical or tangible media, and/or non-transitory storage media. These storage media include different forms of memory including semiconductor memory devices such as DRAM, or SRAM, Erasable and Programmable Read-Only Memories (EPROMs), Electrically Erasable and Programmable Read-Only Memories (EEPROMs) and flash memories; magnetic disks such as fixed, floppy and removable disks; other magnetic media including tape; optical media such as Compact Disks (CDs) or Digital Versatile Disks (DVDs). Note that the instructions of the software discussed above can be provided on computer-readable or machine-readable storage medium, or alternatively, can be provided on multiple computer-readable or machine-readable storage media distributed in a large system having possibly plural nodes. Such computer-readable or machine-readable medium or media is (are) considered to be part of an article (or article of manufacture). An article or article of manufacture can refer to any manufactured single component or multiple components.

[0301] Method blocks discussed herein can be automated and executed by a computer, **computer system, user agent, and/or electronic device.** The term “automated” means controlled operation of an apparatus, system, and/or process using computers and/or mechanical/electrical devices without the necessity of human intervention, observation, effort, and/or decision.

[0302] The methods in accordance with example embodiments are provided as examples, and examples from one method should not be construed to limit examples from another

method. Further, methods discussed within different figures can be added to or exchanged with methods in other figures. Further yet, specific numerical data values (such as specific quantities, numbers, categories, etc.) or other specific information should be interpreted as illustrative for discussing example embodiments. Such specific information is not provided to limit example embodiments.

CLAIMS

What is claimed is:

1. A method executed by a smartphone to generate head related transfer functions (HRTFs) of a person wearing earphones, the method comprising:

capturing, with a camera in the smartphone, an image of a face of the person while the smartphone is located away from but proximate to the face of the person;

determining, based on the image of the face, a location of the smartphone with respect to the face of the person;

generating, from a speaker of the smartphone, a sound while the smartphone is in a hand of the person and at the location that is away from but proximate to the face of the person;

capturing, with a left microphone of the earphones in a left ear of the person and with a right microphone of the earphones in a right ear of the person, the sound generated from the speaker of the smartphone;

generating, with the smartphone, a left HRTF of the person for the location with the sound captured in the left microphone and a right HRTF of the person for the location with the sound captured in the right microphone; and

storing the location of the smartphone with respect to the face of the person when the smartphone generates the sound.

2. The method of claim 1, further comprising:

generating, with the smartphone, a sound localization point (SLP) that corresponds to the location of the smartphone that is in empty space away from but proximate to the face of the person; and

moving, based on the left HRTF and the right HRTF, a voice of a caller to the SLP during an electronic voice exchange when the person talks to the caller with the smartphone.

3. The method of claim 1 further comprising:

calculating, with the smartphone, an azimuth angle (θ) and an elevation angle (Φ) between the smartphone and a line of sight of the person; and
instructing, with the smartphone, the person to place the smartphone at the location that is approximately three feet from the face of the person at (θ , Φ), where θ is 20° to 45° azimuth and Φ is -20° to $+20^\circ$ elevation measured from the line of sight of the person.

4. The method of claim 1 further comprising:

detecting when the speaker of the smartphone is pointed toward the face of the person; and
generating the sound when the speaker is pointed toward the face of the person.

5. The method of claim 1, further comprising:

analyzing the face of the person to determine a distance between the face of the person and the smartphone and an azimuth angle of the smartphone with respect to a line of sight of the person; and
automatically generating the sound when the smartphone is at a predetermined distance from the face of the person and at a predetermined azimuth angle with respect to the line of sight of the person.

6. The method of claim 1, wherein the sound is a specific sound to measure audio impulse responses at the left ear and the right ear of the person, and the sound includes one of a frequency-swept sine wave, a maximum length sequence (MLS), and a Golay code.

7. The method of claim 1, further comprising:

recording a global positioning system (GPS) location of the smartphone when the speaker of the smartphone generates the sound;
generating a sound localization point (SLP) at the location that is away from but proximate to the face of the person;

associating the GPS location with the SLP at the location in order to retrieve the SLP when the smartphone is at the GPS location; and

convolving a voice of a caller to localize at the SLP to the person when the caller calls the person on the smartphone.

8. A method executed in a computer system to generate a sound localization point (SLP) from binaural room impulse responses (BRIRs) of a person from sound generated by a smartphone, the method comprising:

generating, from a speaker in the smartphone, a sound while the smartphone is at a location that is away from but proximate to a face of the person;

capturing audio impulse responses of the sound with a left microphone of earphones in a left ear of the person and with a right microphone of the earphones in a right ear of the person;

determining, with the computer system, a left BRIR of the person from the audio impulse responses captured in the left microphone and a right BRIR of the person from the audio impulse responses captured in the right microphone;

generating, with the computer system, the SLP that corresponds to the location of the smartphone when the smartphone generated the sound while being away from but proximate to the face of the person; and

providing, through the earphones worn by the person, binaural sound such that the binaural sound localizes to the person at the SLP that is in empty space away from but proximate to the face of the person.

9. The method of claim 8, further comprising:

generating multiple SLPs around the face of the person such that the multiple SLPs form a general shape of a semi-circle with an average radius greater than three feet but less than eight feet when the face of the person is at a center of a circle defined by the semi-circle.

10. The method of claim 8, further comprising:

capturing, with the smartphone, an image of the face of the person to determine an

azimuth angle between a forward facing direction of the face of the person and the location of the smartphone; and
automatically generating the sound when the azimuth angle is 20° to 45°.

11. The method of claim 8, further comprising:

generating, from the speaker in the smartphone, the sound while the smartphone is at multiple different locations that are proximate to the face of the person;

determining, with the computer system, a left BRIR and a right BRIR for each of the multiple different locations;

generating, with the computer system and based on the left BRIR and the right BRIR for each of the multiple different locations, a SLP for each one of the multiple different locations; and

displaying SLPs at the multiple different locations on a display to the person.

12. The method of claim 8 further comprising:

generating, from the speaker in the smartphone, the sound when the smartphone is attached to an end of a movable pole that is held in a hand of the person and that extends a distance of the smartphone held by the person to greater than one meter away from the face of the person.

13. The method of claim 8 further comprising:

tracking, with the smartphone, a location of the person; and

selecting the SLP as a localization point to place a voice of a caller when the person is proximate to the location where the smartphone generated the sound.

14. A method executed by a computer system to convolve sound to sound localization points (SLPs) that are away from but proximate to a person with a smartphone, the method comprising:

generating, from a speaker in the smartphone, sounds while the smartphone is moved around to different locations that are away from but proximate to a face of the person;

capturing audio impulse responses of the sounds with microphones that are located in earphones in a left ear and a right ear of the person;

determining, with the computer system and based on the audio impulse responses captured with the microphones, a set of transfer functions at each of the different locations;

associating, with the smartphone, a SLP for each one of the different locations;

convolving, with the smartphone and based on the set of transfer functions, voices so the voices localize to one or more of the SLPs; and

providing, through the earphones worn by the person and after convolving the voices, the voices so the voices localize by the person to the one or more SLPs, wherein the SLPs are located away from but proximate to a face of the person.

15. The method of claim 14, further comprising:

generating, from the speaker in the smartphone, the sounds while the person holds one end of a selfie stick and the smartphone is attached to an opposite end of the selfie stick.

16. The method of claim 14, further comprising:

generating, from the speaker in the smartphone, one of the sounds while the smartphone is about three feet from the face of the person and within an azimuth angle of 20° to 45° from a forward looking direction of the person.

17. The method of claim 14, wherein the sounds generated from the speaker in the smartphone are a tone or a pulse from which a binaural room impulse response (BRIR) is computed for each of the different locations.

18. The method of claim 14, further comprising:

capturing an image of the person at each of the different locations that are away from but proximate to the face of the person;

determining, based on the image of the person at each of the different locations, a facial orientation of the person; and

storing the facial orientation of the person at each of the different locations, wherein the facial orientation includes an azimuth angle and an elevation angle of the face of the person with respect to a location of the smartphone when the smartphone generated the sounds.

19. The method of claim 14, further comprising:

dividing an area around the face of the person into different zones;

determining if one of the zones already has a designated SLP in the one of the zones; and

instructing the person to generate a SLP for the zone when the zone does not have the designated SLP.

20. The method of claim 14, further comprising:

receiving, with the smartphone, a telephone call from a calling person;

selecting, with the smartphone, a first SLP of one of the different locations;

placing, with the smartphone, a voice of the calling person to the first SLP; and

moving, with the smartphone, the voice of the calling person from the first SLP to a second SLP in response to a command from the person during the telephone call, wherein the first SLP and the second SLP are locations in empty space that are proximate to the face of the person.

ABSTRACT

A method captures audio impulse responses of a person wearing electronic microphones in a left ear and a right ear. A smartphone generates a sound while it is away from but proximate to the person. The microphones capture the audio impulse responses that are used to convolve sound so it localizes away from but proximate to the person.

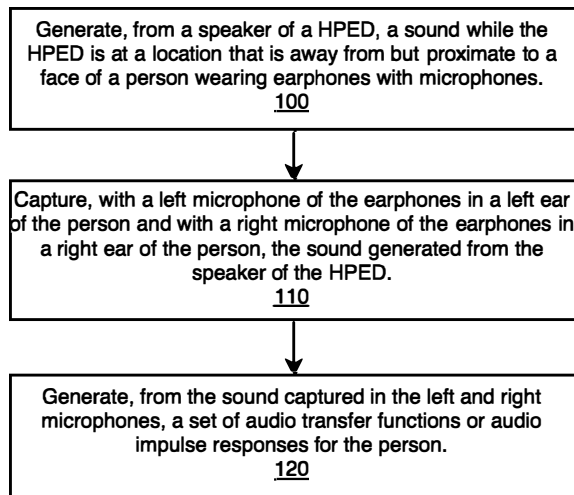


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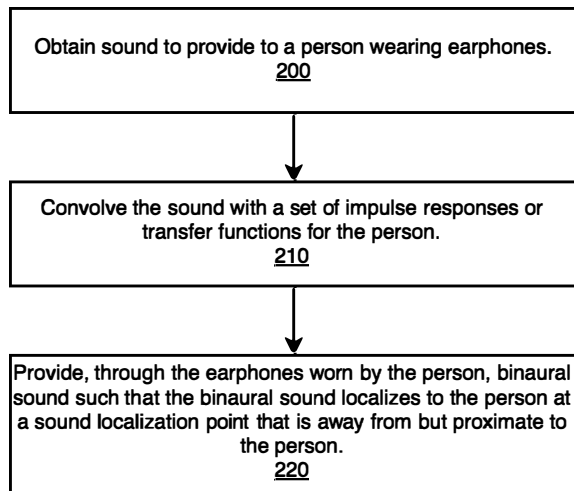


Figure 2

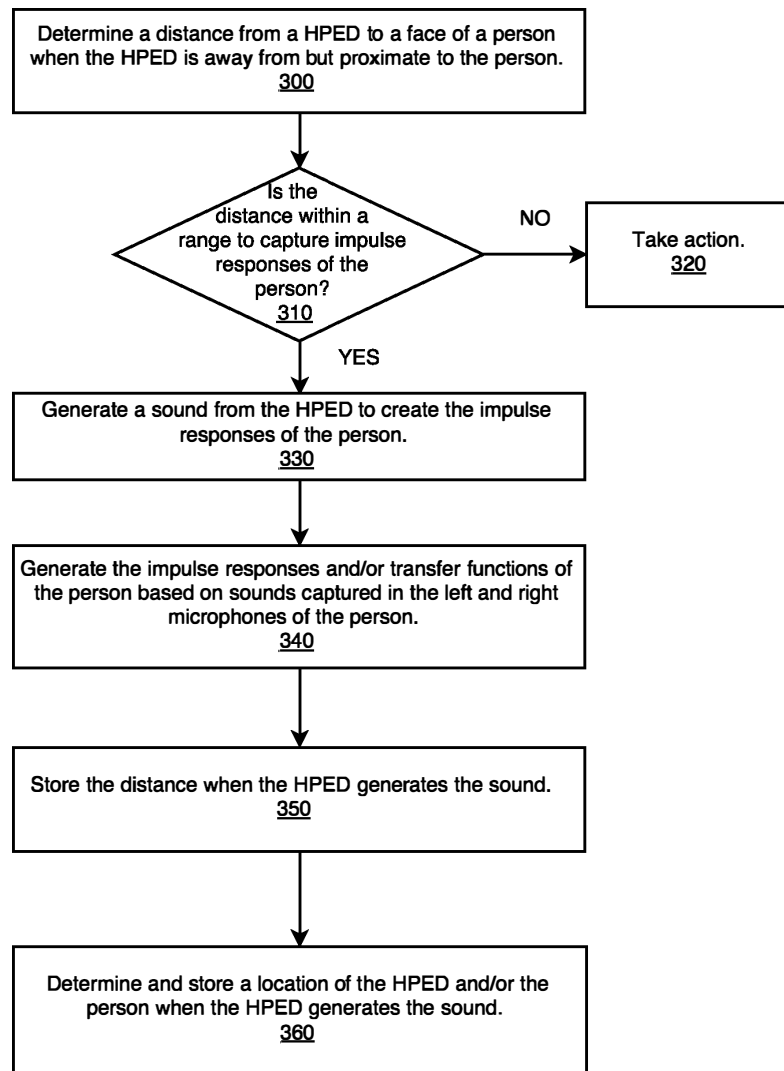


Figure 3

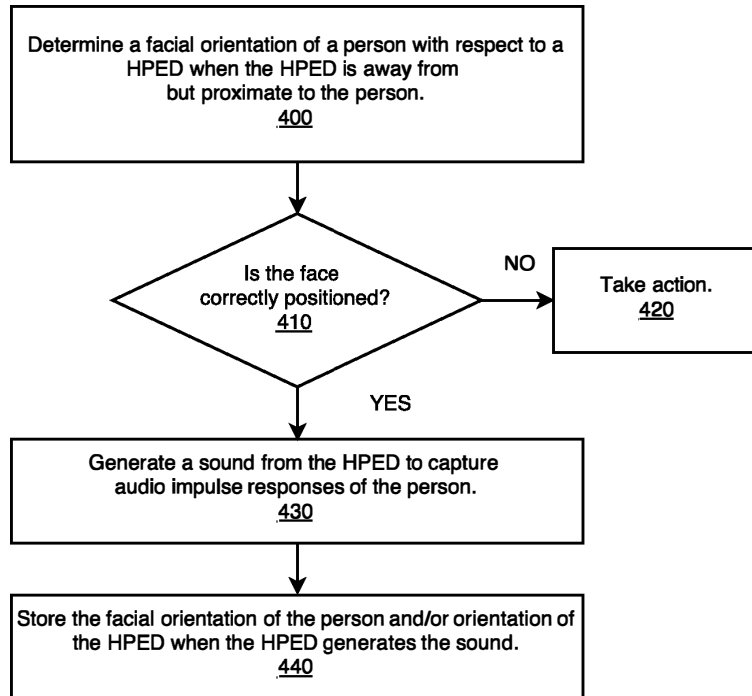


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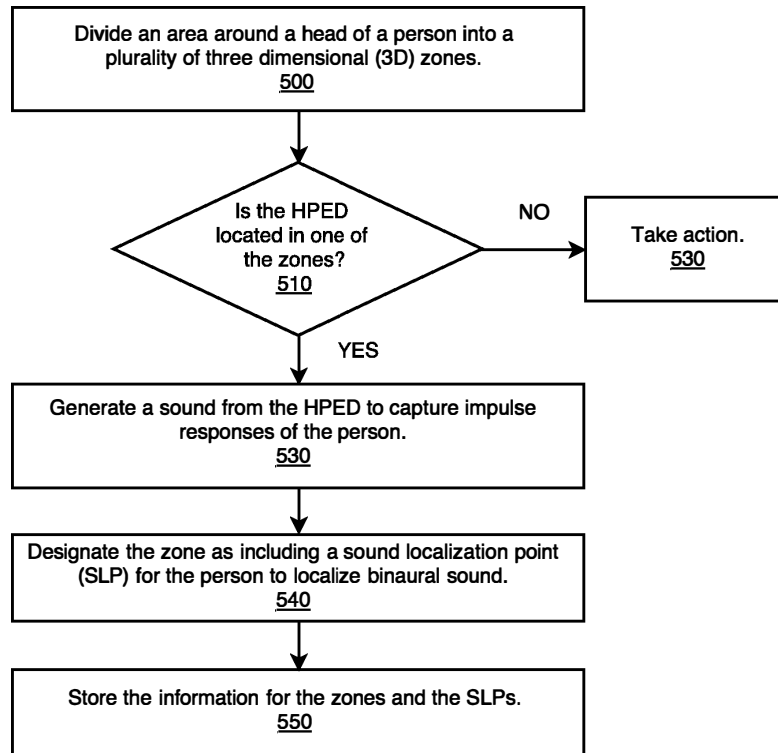


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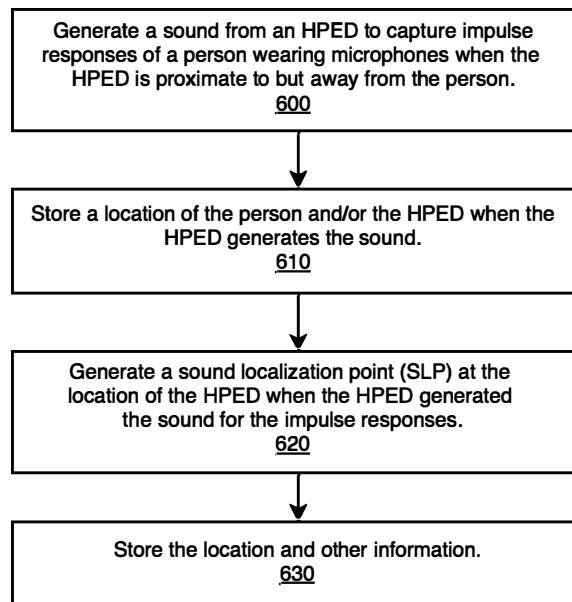


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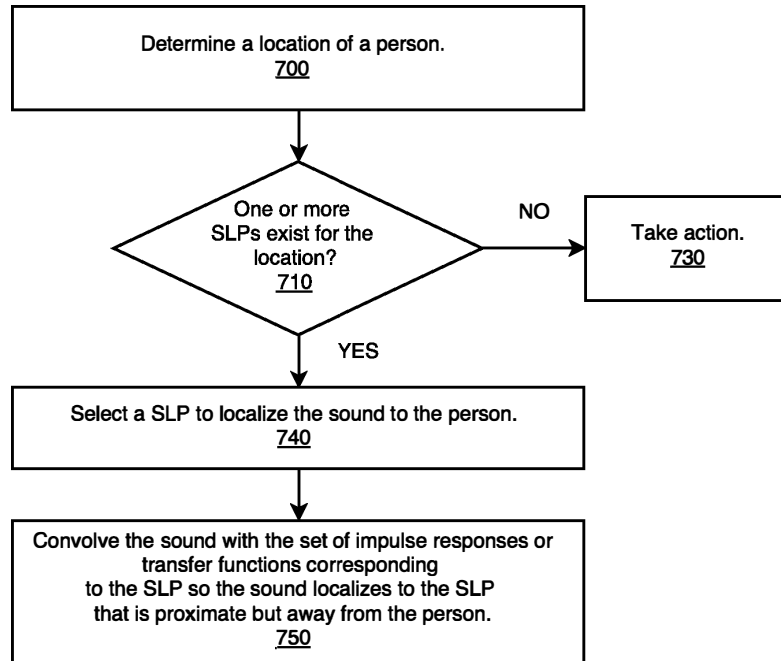


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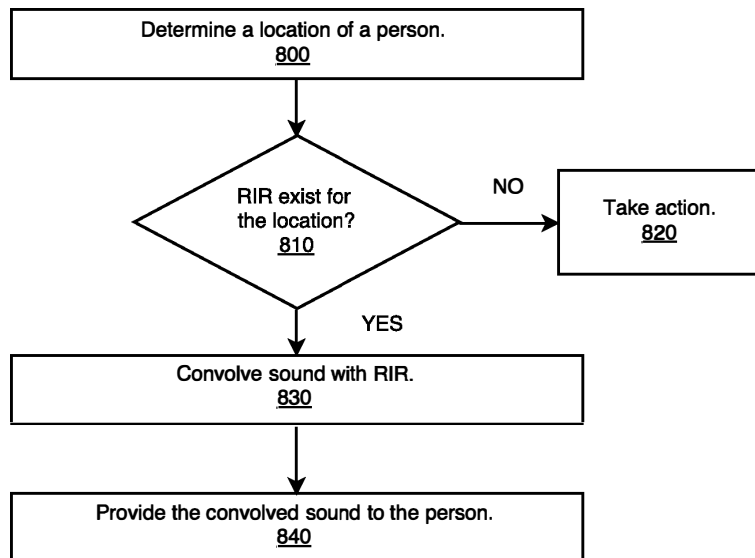


Figure 8

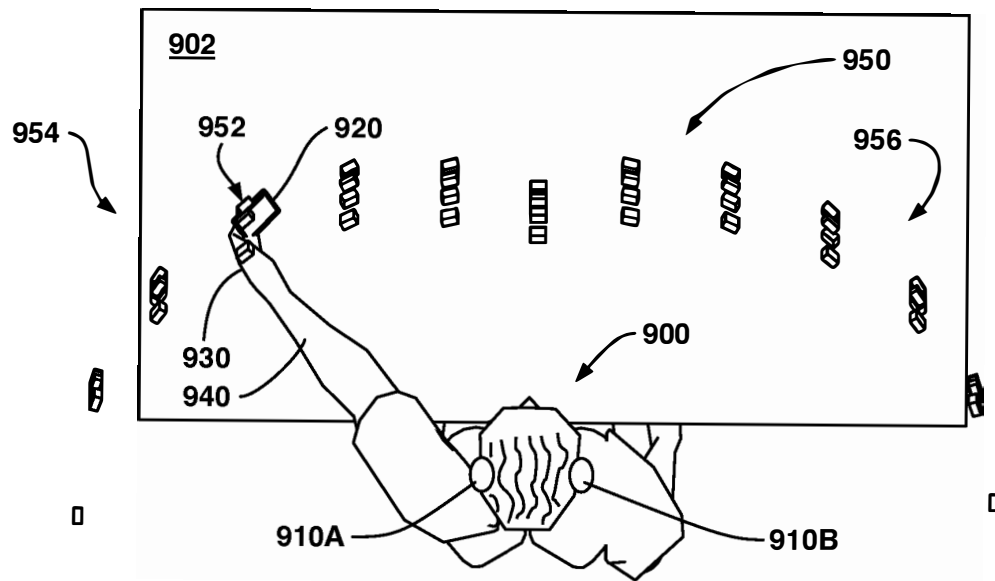


Figure 9A

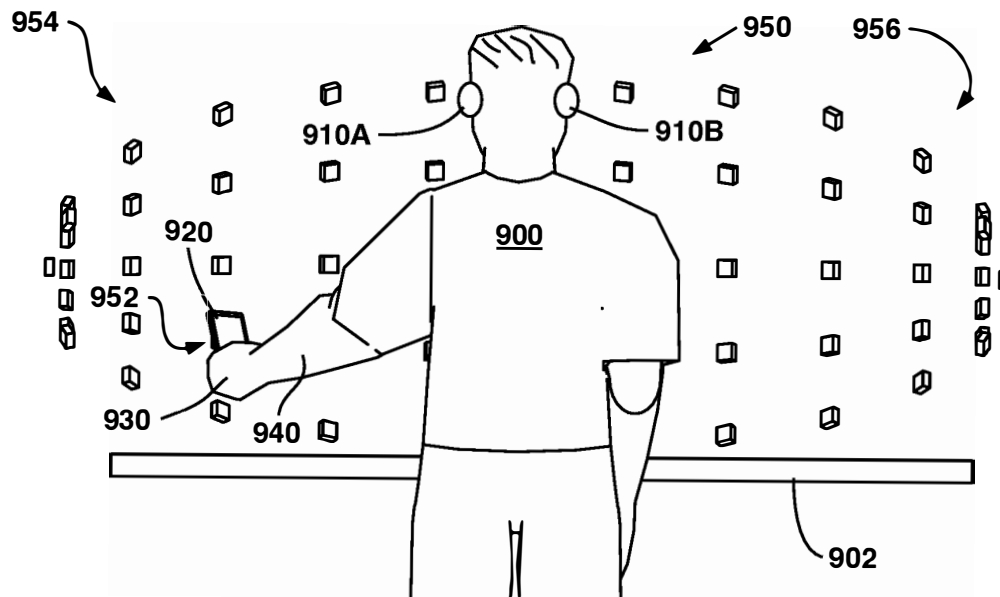


Figure 9B

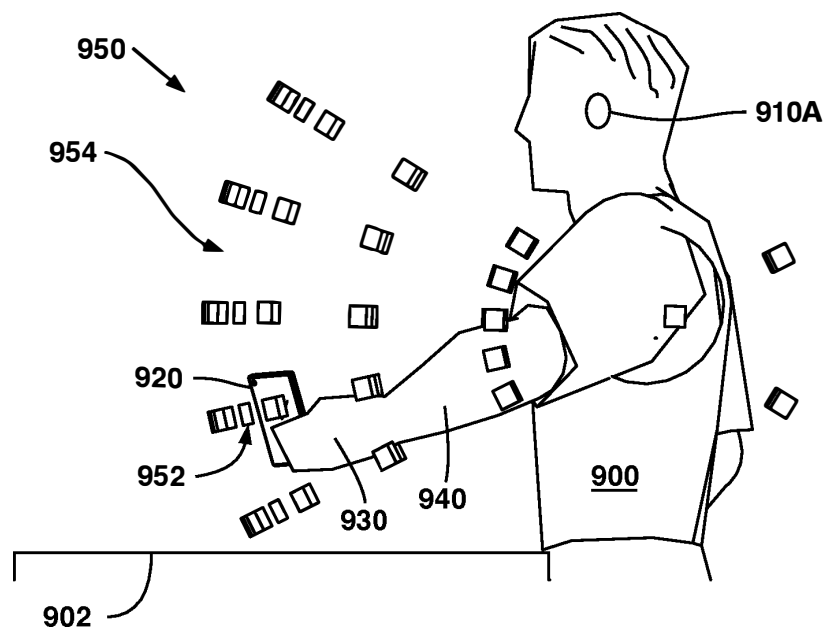


Figure 9C

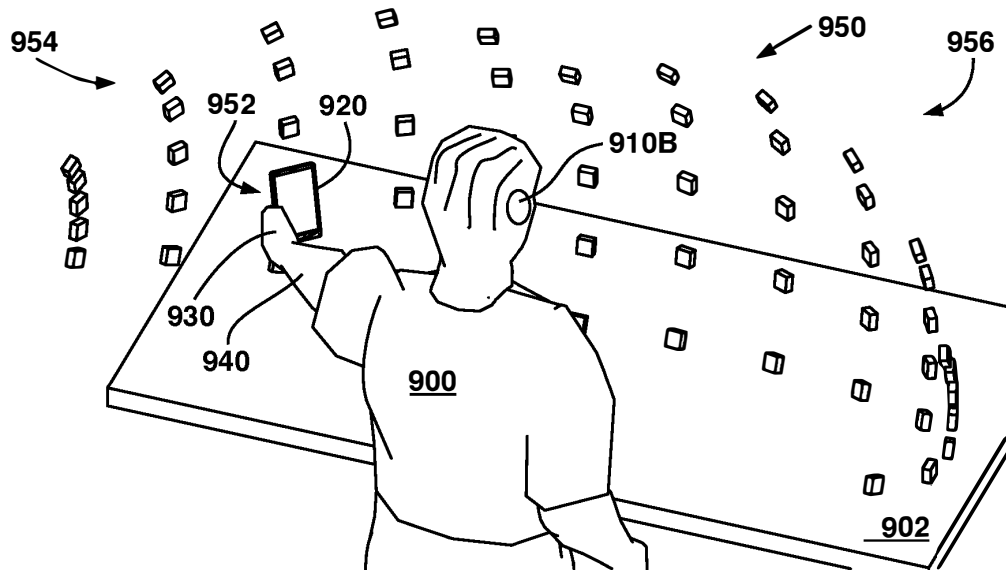


Figure 9D

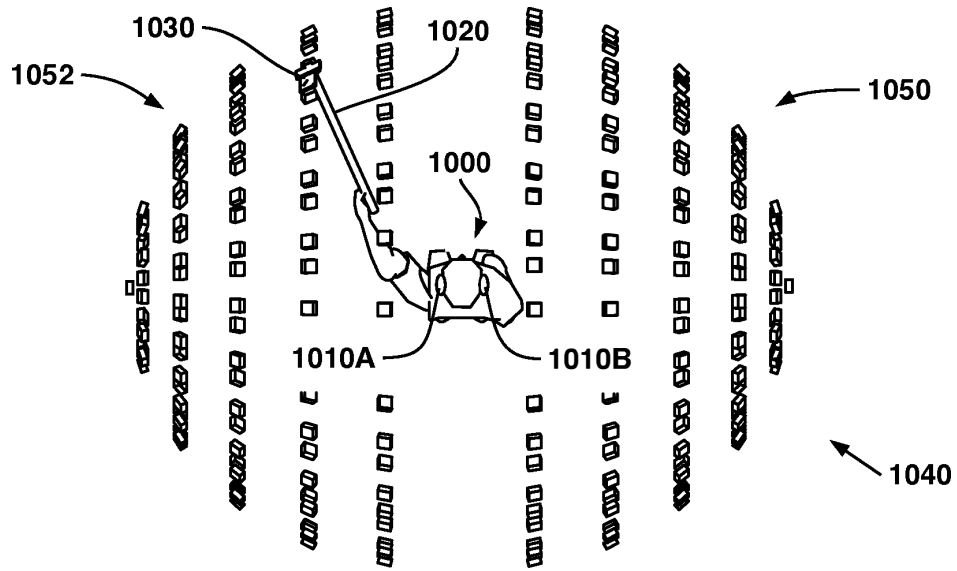


Figure 10A

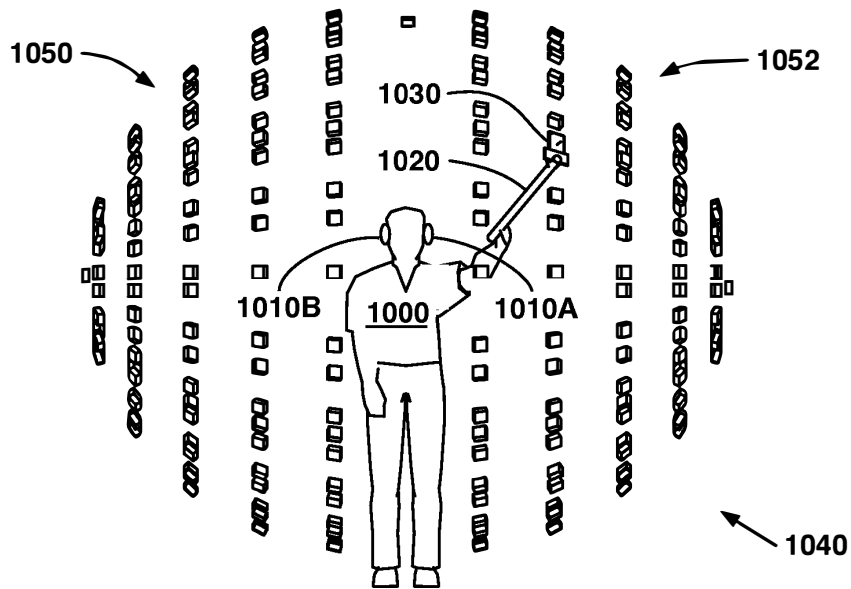


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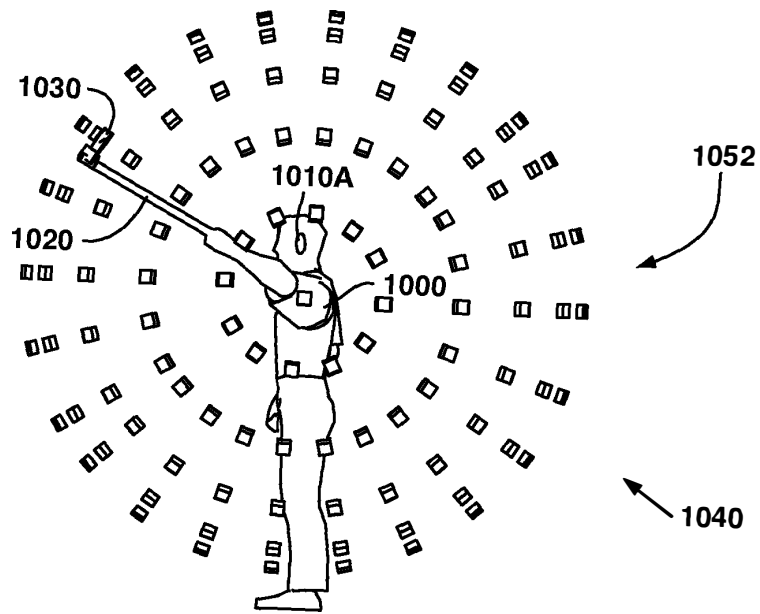


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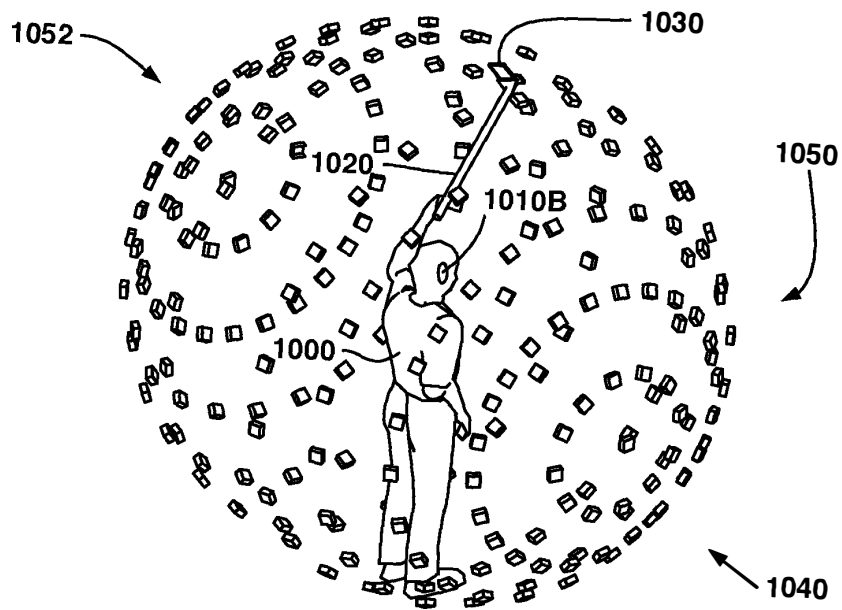


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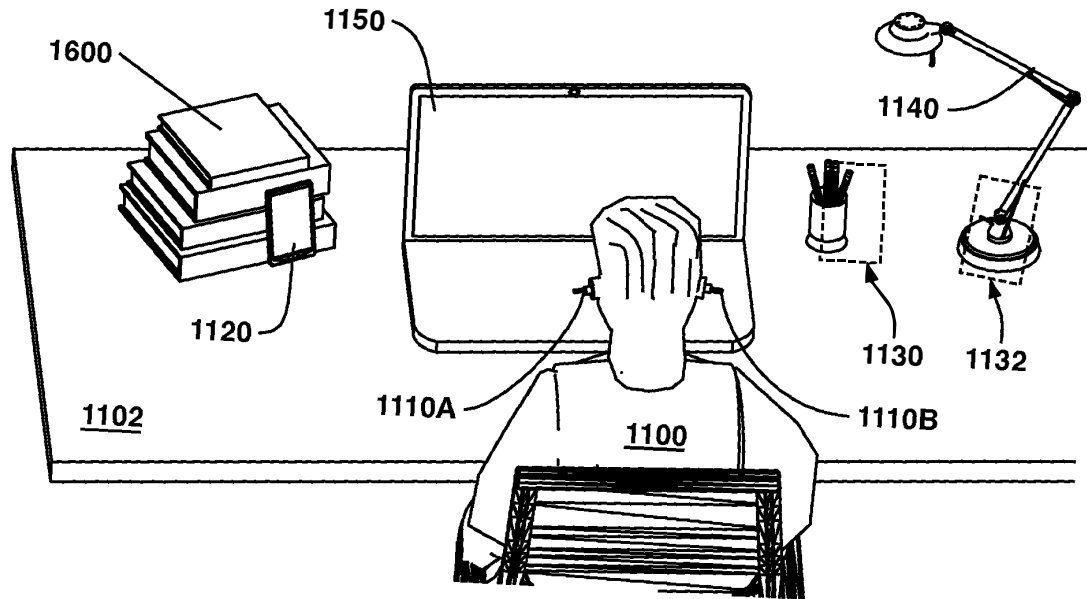


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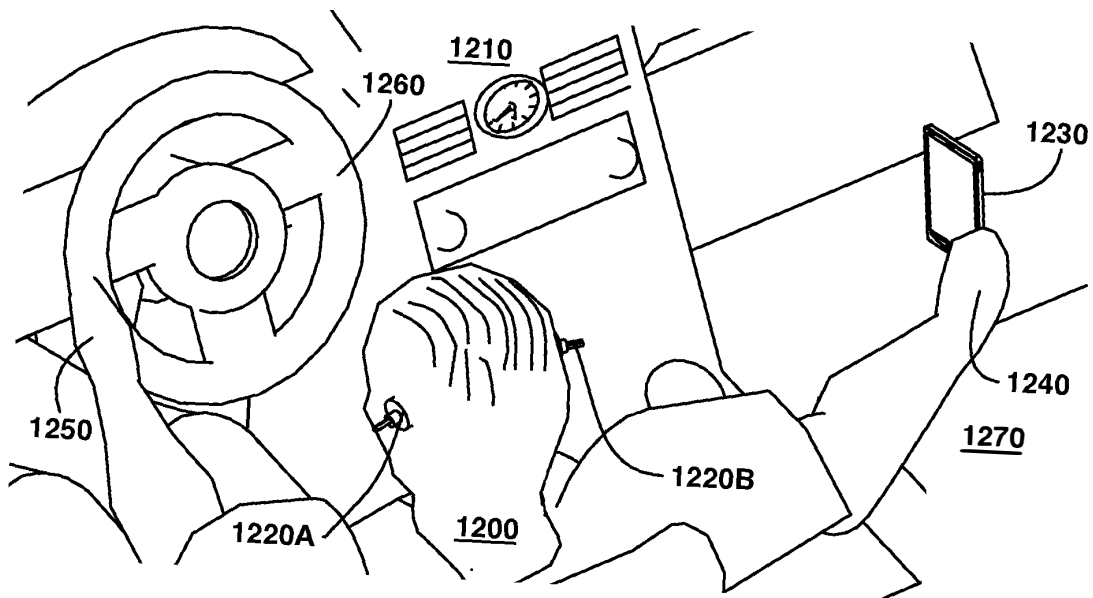


Figure 12

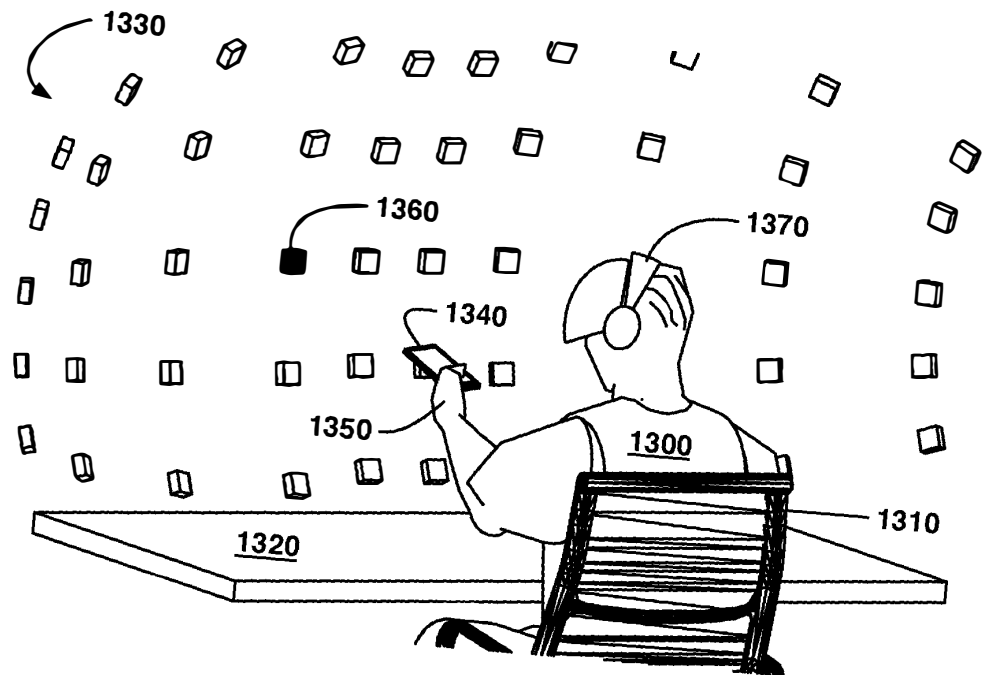


Figure 13

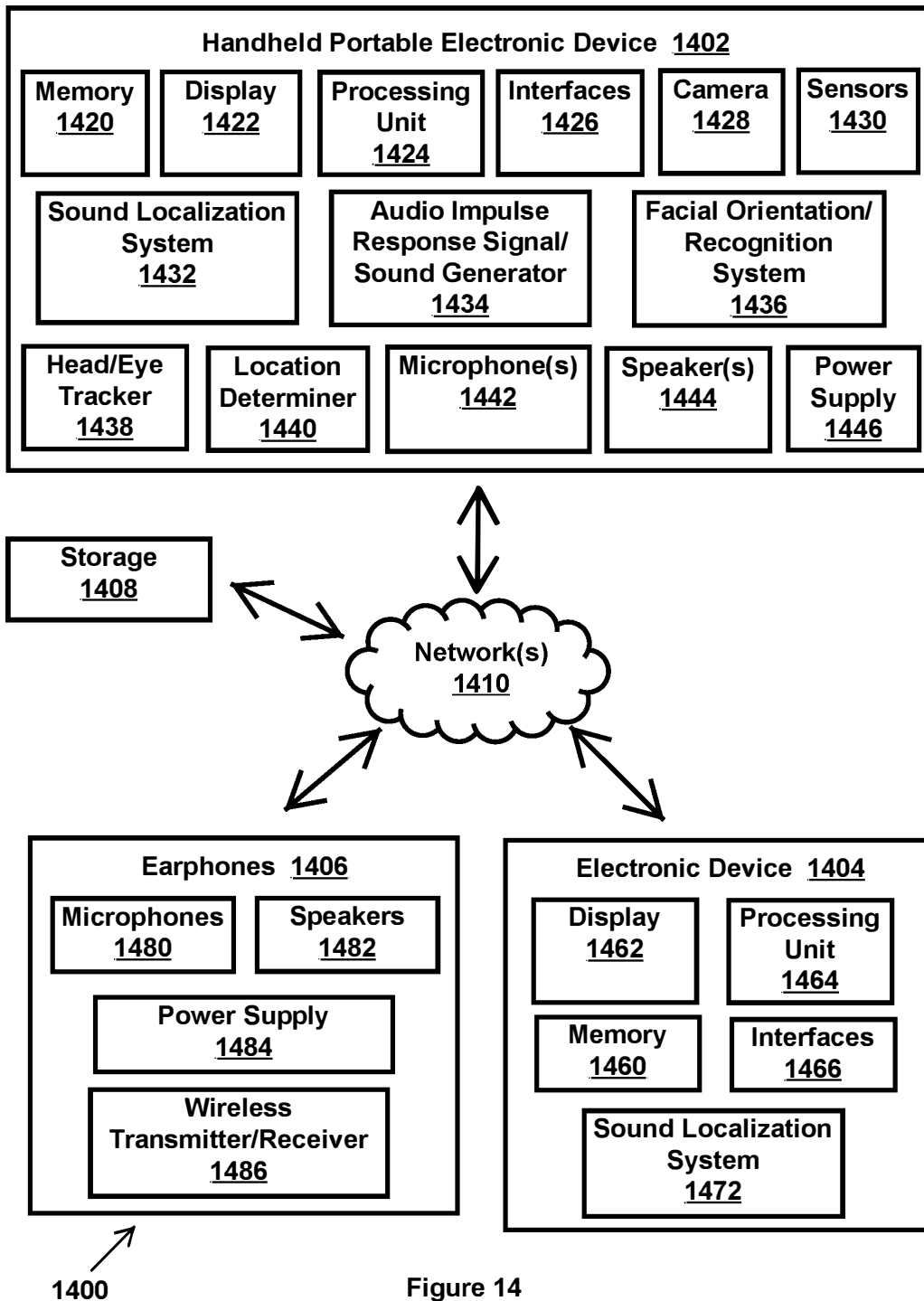


Figure 14

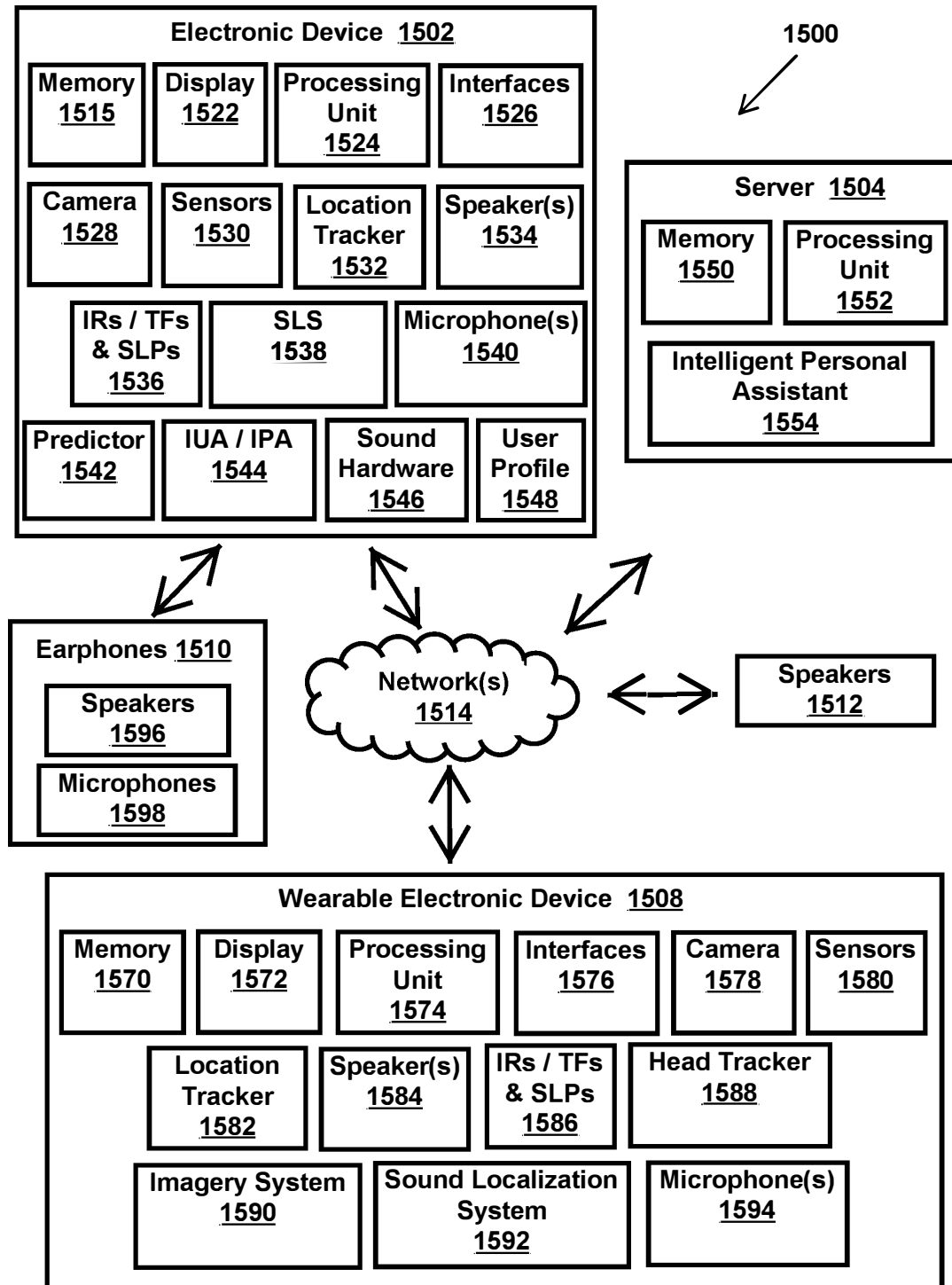


Figure 15

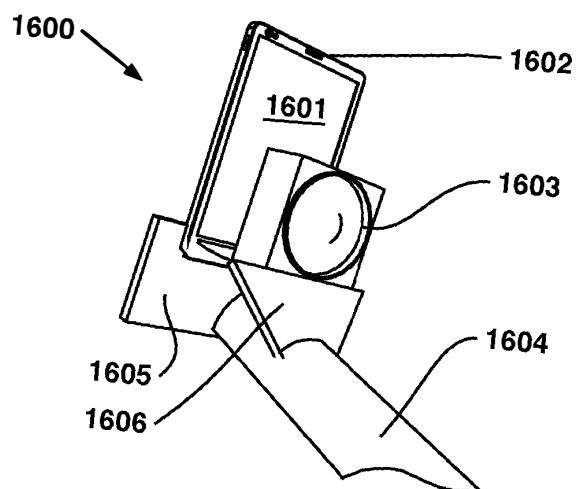


Figure 16

Electronic Patent Application Fee Transmittal				
Application Number:				
Filing Date:				
Title of Invention:		Capturing Audio Impulse Responses of a Person with a Smartphone		
First Named Inventor/Applicant Name:		Philip S Lyren		
Filer:		Philip Scott Lyren		
Attorney Docket Number:		PSL-038 (CON 7)		
Filed as Small Entity				
Filing Fees for Utility under 35 USC 111(a)				
Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Basic Filing:				
UTILITY FILING FEE (ELECTRONIC FILING)	4011	1	80	80
UTILITY SEARCH FEE	2111	1	350	350
UTILITY EXAMINATION FEE	2311	1	400	400
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
Total in USD (\$)				830

Electronic Acknowledgement Receipt	
EFS ID:	40754009
Application Number:	17062633
International Application Number:	
Confirmation Number:	2402
Title of Invention:	Capturing Audio Impulse Responses of a Person with a Smartphone
First Named Inventor/Applicant Name:	Philip S Lyren
Customer Number:	64021
Filer:	Philip Scott Lyren
Filer Authorized By:	
Attorney Docket Number:	PSL-038 (CON 7)
Receipt Date:	05-OCT-2020
Filing Date:	
Time Stamp:	00:04:37
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	DA
Payment was successfully received in RAM	\$830
RAM confirmation Number	E202005105139664
Deposit Account	
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Transmittal of New Application	Transmittal.pdf	91238	no	1
			4184a1d7bc6bfabe265da67b039e1993acd fa2d0		

Warnings:**Information:**

2	Power of Attorney	power_attorney.pdf	1135443	no	1
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Warnings:**Information:**

3	Application Data Sheet	Application_Data_Sheet.pdf	1819197	no	8
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Warnings:**Information:**

4	Oath or Declaration filed	Declaration.pdf	2118171	no	3
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5	Specification	Specification.pdf	1345212	no	73
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6	Claims	Claims.pdf	52689	no	6
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7	Abstract	Abstract.pdf	7784	no	1
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Warnings:					
Information:					
8	Drawings-only black and white line drawings	Drawings.pdf	2275901	no	14
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9	Fee Worksheet (SB06)	fee-info.pdf	35042	no	2
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Warnings:					
Information:					
Total Files Size (in bytes):			8880677		
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