

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

META PLATFORMS, INC.,
Petitioner,

v.

MULLEN INDUSTRIES LLC,
Patent Owner.

Case IPR2025-00744
U.S. Patent No. 12,019,791 B2
Issue Date: June 25, 2024

Title: AUGMENTED REALITY VIDEO GAME SYSTEMS

DECLARATION OF INGRID HSIEH-YEE, PH.D.

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I, Ingrid Hsieh-Yee, declare as follows:

I. INTRODUCTION AND QUALIFICATIONS

1. I am over the age of eighteen and otherwise competent to make this declaration.

2. I have been retained by counsel for Petitioner to provide my expert opinion in connection with the above-captioned proceeding (“IPR”) regarding the public availability of a certain prior art references in relation to U.S. Patent No. 12,019,791 B2 (“Challenged Patent”).

3. I am being compensated for my time in connection with this IPR at my current consulting rate. I am also being reimbursed for any reasonable expenses associated with my work and testimony in this investigation. My compensation is not contingent on the results of my study, the substance of my opinions, or the outcome of this matter.

A. Qualifications and Professional Experience

4. My complete qualifications and professional experience are described in my academic curriculum vitae (**Appendix A**). The following is a brief summary of my relevant qualifications and professional experience.

5. I was a professor in the Department of Library and Information Science at the Catholic University of America for 32 years and was conferred the title of Professor Emerita in December 2022. I have experience working in an academic

library, a medical library, and a legislative library. I hold a Ph.D. and a Masters in Library and Information Studies from the University of Wisconsin-Madison.

6. I am an expert on library cataloging and classification and have published two editions on this subject, *Organizing Audiovisual and Electronic Resources for Access: A Cataloging Guide* (2000 and 2006). I taught a variety of courses, including Cataloging and Classification, Advanced Cataloging and Classification, Organization of Internet Resources, Organization of Information, Metadata, Digital Content Creation and Management, Internet Searches and Web Design, Information Literacy Instruction, Advanced Information Retrieval and Analysis Strategies, and The Information Professions in Society. I am familiar with metadata schema design and implementation. In my teaching, I covered the design and implementation of metadata in databases, search engines, digital repositories, digital libraries, and digital archives. I also covered how information organization affects the discovery and access to digital resources on the Internet. My research interests cover cataloging and classification, information organization, metadata, information retrieval, information architecture, digital collections, scholarly communication, social media, user interaction with information systems, and others

II. BACKGROUND OF LIBRARY CATALOGING

A. Machine-Readable Cataloging (“MARC”)

7. I am very familiar with a library cataloging encoding standard known

as the “Machine-Readable Cataloging” standard, also known as “MARC,” which became the national standard for sharing bibliographic data in the United States by 1971 and the international standard by 1973. MARC is the primary communications protocol for the transfer and storage of bibliographic metadata in libraries. Experts in my field reasonably rely upon MARC records when forming their opinions.

8. A MARC record consists of several fields, each of which contains specific data about the work. Each field is identified by a standardized, unique, three-digit code corresponding to the type of data that follows. **Appendix B** is a true and correct copy of Parts VII to X of “Understanding MARC Bibliographic: Machine-Readable Cataloging” (<https://www.loc.gov/marc/umb/um07to10.html>), a brief description and tutorial published by the Library of Congress in 2009 that explains commonly used MARC fields. For example, the personal author of a work is recorded in Field 100, the title is recorded in Field 245, publisher information is recorded in Field 260, the physical volume and characteristics of a publication are recorded in Field 300, and topical subjects are recorded in Fields 650. More details of MARC21 format for Bibliographic Data are available on the Library of Congress website at <https://www.loc.gov/marc/bibliographic/>.

9. I am very familiar with library cataloging and processing practices and the relationships between OCLC (Online Computer Library Center) and library catalogs, and how libraries create and share their records to help the public discover

and access information.

10. OCLC is the largest bibliographic network of the world, and its WorldCat database contains more than 559 million records from thousands of member institutions (many of which are libraries of some type) in more than 100 countries. OCLC was founded in 1967 to promote and support library cooperation. According to the third article of the “Amended Articles of Incorporation of OCLC [Online Computer Library Center], Inc.,” OCLC was created “to establish, maintain, and operate a computerized library network and to promote the evolution of library use, of libraries themselves, and of librarianship, and to provide processes and products for the benefit of library users and libraries, including such objectives as increasing availability of library resources to individual library patrons and reducing the rate of rise of library per-unit costs, all for the fundamental public purpose of furthering ease of access to and use of the ever-expanding body of worldwide scientific, literary, and educational knowledge and information” (source: <https://www.oclc.org/content/dam/oclc/membership/articles-of-incorporation.pdf>).

11. OCLC members can contribute original cataloging records in MARC to the system or derive cataloging records from existing records, an activity referred to as “copy cataloging.” When an OCLC participating institution acquires a work, it can create an original MARC record for the work in OCLC’s Connexion system (a system for catalogers to create and share MARC records), and the system will

automatically generate a code for the date of record creation in the yymmdd format, and the creating library's OCLC symbol is recorded in subfield "a" of the 040 field. Once the MARC record is in Connexion, it becomes available to other OCLC members for adoption to their local online catalogs (*i.e.*, copy cataloging).

12. After a MARC record is created in Connexion, it also becomes searchable and viewable on WorldCat.org, which is a free web portal for users to explore more than 10,000 libraries worldwide. Records in WorldCat.org, however, are not presented in MARC fields. Instead, the data elements are labeled to help users interpret the records. Thus, the information stored in MARC records in Connexion is available to the interested public through the user-friendly WorldCat web portal.

B. Library Online Catalogs

13. Library online catalogs gained acceptance in the early 1980s and many libraries migrated their systems to the World Wide Web in the mid-1990s. Library online catalogs are based on MARC records that represent their collections in order to help the public understand what materials are publicly accessible in those libraries. Most libraries with online catalogs have made their catalogs freely available on the Web. These online catalogs offer user-friendly search interfaces. Strong user interest in keyword searches and the popularity of Google have led to the "googlization" of library search systems. As a result, many library catalogs nowadays provide a single search box for users to conduct keyword searches, with additional support for

searches by author, title, subject terms, and other data elements such as ISBN (International Standard Book Number). Library catalogs these days also offer features for users to narrow their search results by language, year, format, and other elements. Many libraries display MARC records on their online catalogs with labels for the data elements to help the public interpret MARC records. Many libraries also offer the option to display MARC records in MARC fields.

14. Libraries create MARC records for works they acquire, including books, serials, motion pictures, and publications in other formats. Monograph cataloging is fairly common in libraries, and most libraries make a newly cataloged monograph available to the public soon after the cataloging work is completed, usually within a week. Libraries can create original cataloging records or use an existing record in the OCLC WorldCat database to create a copy cataloging record. As soon as the cataloging record is completed, it is added to the library's online catalog for users. If the record is an original record, it is also entered into the OCLC system. If it is a copy cataloging record, the library's holding symbol is attached to the existing original record in the OCLC system to facilitate searching and interlibrary loan.

15. I am personally familiar with many online catalogs, databases, and search engines. In preparing for this declaration, I used the following authoritative information systems to search for records:

- Google Scholar (<https://scholar.google.com/>)
- IEEE Xplore (<https://ieeexplore.ieee.org/Xplore/home.jsp>)
- Internet Archive (<https://archive.org/>)
- Libraries.org, a directory of libraries throughout the world (<https://librarytechnology.org/libraries/>)
- Online catalog of the Linda Hall Library (https://catalog.lindahall.org/discovery/search?vid=01LINDAHALL_I NST:LHL)
- Public catalog of the US Copyright Office (<https://cocatalog.loc.gov/cgi-bin/Pwebrecon.cgi?DB=local&PAGE=First>)
- WorldCat.org (<https://search.worldcat.org/>)

C. Scope of this Declaration

16. I have been asked to offer an opinion on the public availability date of the following document:

Kanbara, M., Okuma, T., Takemura, H., & Yokoya, N. (2000, March). A stereoscopic video see-through augmented reality system based on real-time vision-based registration. In *Proceedings IEEE Virtual Reality 2000*, pp. 255-262, **EX1006** (“Kanbara”).

17. I am informed by counsel and. Understand that a given reference is

“published” upon a satisfactory showing that such a document has been disseminated or otherwise made publicly available to the extent that persons interested and ordinarily skilled in the subject matter or art could locate it exercising reasonable diligence and obtain the document. I have also been informed by counsel and understand that materials available in a library constitute “printed publications” if they are catalogued and indexed according to general library practices and protocols that make the references available and accessible to members of the interested public.

18. I have been informed by counsel that the Challenged Patent claims October 11, 2007, as its earliest priority date. I have assessed public accessibility of the documents referenced below as of this claimed priority date.

19. I have been informed by counsel that the subject matter of this proceeding generally relates to virtual and augmented reality computing systems.

20. I have been informed by counsel that a “person of ordinary skill in the art at the time of the invention” (POSA) is a hypothetical person who is presumed to be familiar with the relevant field and its literature at the time of the inventions. I have been informed by counsel that this hypothetical person is also a person of ordinary creativity, capable of understanding the scientific principles and literature applicable to the pertinent field.

21. I have been informed by counsel that a person of ordinary skill in the art as of October 11, 2007, would have knowledge of the scientific literature and have

skills relating to virtual and augmented reality computing systems. A person of ordinary skill would have possessed a bachelor's degree in electrical engineering, computer science, or similar field, with two years combined experience in designing and/or developing interactive location-based computer systems/software, such as video games or other simulations incorporating location information (such as GPS information associated with a user's physical location), and in designing and/or developing computer systems/software involving graphical virtual and/or augmented reality. A person could also have qualified as a person of ordinary skill in the art with some combination of (1) more formal education (such as a master's of science degree) and less technical experience, or (2) less formal education and more technical or professional experience.

22. It is my opinion that such a person would have been actively engaged in learning about the field, possibly through formal instruction and through bibliographic resources. By at least October 11, 2007, such a person would have had access to a vast array of print and electronic resources, including at least the documents referenced below.

D. Evidence Considered in Forming My Opinion

23. In the preparation of this declaration, I have reviewed **EX1006** referenced in paragraph 16 above, and any other documents I reference herein. Each of these is a type of material that experts in my field would reasonably rely upon

when forming their opinions. I provided a further description of materials I considered in **Appendix C**.

III. Authentication and Public Availability of *Kanbara* (EX1006)

A. Authentication

24. **Exhibit 1006** is a true and correct copy of “A stereoscopic video see-through augmented reality system based on real-time vision-based registration,” (“*Kanbara*”), by Kanbara et al., in *Proceedings IEEE Virtual Reality 2000*, pp. 255-262, that I obtained from the Linda Hall Library. This copy is presented as **EX1006** in this declaration.

25. Page 1 is the cover that shows the conference name, dates, location, editors, sponsor, and publisher. Page 2 is the title page that shows the same information as the cover and also indicates this publication is the “Proceedings” of the conference and the publisher has several offices in several cities around the world. Page 3 is the copyright page that shows a “2000” copyright date and The Institute of Electrical and Electronics Engineers, Inc. as the copyright holder. The top of the page shows a hand-written call number of “QA76.9 .V5I143 2000.” This page shows “PRO00478” as the IEEE Computer Society order number for this work, “0-7659-0478-7” and “0-7659-0480-9” (for microfiche) as the ISBNs (International Standard Book Numbers), and “1087-8270” as the ISSN (International Standard Serial Number. Pages 4 (internal page v) to 8 (internal page ix) are the table of contents and

page 4 carries a library stamp and the left side of this page shows a date annotation of “4-10-00” (*i.e.*, April 10, 2000) that indicates the Linda Hall Library added this work to their collections on this date. The knowledge of this date annotation practice is based on my personal knowledge and experience with the Linda Hall Library and its collections. Page 7 (internal page viii) shows *Kanbara* is included in “Paper Session 10: Mixed Reality and Tracking” and begins on page 255. Pages 9 to 16 are the full text of *Kanbara*. Page 9 (internal page 255) shows the title, authors, and abstract, and the bottom of this page shows that *Kanbara* appears in a work that has “0-7695-0478-7” as its ISBN, that the article has a “2000” copyright date, and IEEE is the copyright holder. **EX1006** shows *Kanbara* has a total of eight pages, including eight figures and 18 references.

26. To authenticate **EX1006**, I located a metadata record for *Kanbara* from IEEE Xplore at <https://ieeexplore.ieee.org/abstract/document/840506> and used it to obtain a PDF of this article. This IEEE copy is presented as **EX1006A** in this declaration. **EX1006A** shows this article has a total of eight pages, including eight figures and 18 references. I have closely compared the Linda Hall Library copy (**EX1006**) with the IEEE copy (**EX1006A**), and found them to contain the same content for *Kanbara*. These two copies are different in that the IEEE copy does not include the ISBN and copyright information on the first page of this article, pages in the IEEE copy are not numbered, and some images in the IEEE copy are in color.

27. **EX1006** is in a condition that raises no suspicion about its authenticity. Specifically, this copy is not missing any intermediate pages, and there are no visible alterations to the document. Furthermore, this library copy has the same content as the IEEE copy (**EX1006A**), and is held by a well-known public research library. Based on my review and analysis, it is my opinion that **EX1006** is authentic.

B. Records of Linda Hall Library

28. To determine the public availability date of that contains *Kanbara* at libraries, I obtained records for this work from the online catalog of the Linda Hall Library. **EX1006B** is a true and correct copy of the bibliographic and MARC records for this work. I personally located, identified, and obtained these records. They are the type of records experts in my field would reasonably rely upon when forming their opinions.

29. Pages 1 to 4 of **EX1006B** are the bibliographic record. Page 1 shows "conference proceeding" is the format of this work, and it is cataloged as a book and is available at "Linda Hall Library Books – 2nd Floor (QA76.9.V5I143 2000)." The record details include the title, conference name, editors, and sponsor, subjects, four ISBNs, an OCLC number, publisher, creation date, physical details, and three general notes. The title, conference name, editors, sponsor, two 10-digit ISBNs, and publisher information match the information presented in **EX1006**, confirming this record represents *Proceedings of the IEEE Virtual Reality 2000* that contains *Kanbara*.

30. Pages 5 and 6 are the MARC record. The first six digits of Field 008 show the record was created on “000411” (*i.e.*, April 11, 2000). Subfields ‘a’ and ‘c’ of Field 040 show “LHL” created the original record and entered it into the OCLC WorldCat database. According to the *Directory of OCLC Members* (<https://www.oclc.org/en/contacts/libraries.html>), “LHL” is the OCLC library symbol for the Linda Hall Library. Based on the data in Fields 008 and 040, it is my opinion that the Linda Hall Library created the original record for the conference proceedings containing *Kanbara* on April 11, 2000, making this work discoverable in their online catalog from that date on. A customary library practice is to process a newly cataloged monograph promptly for public access, usually within a week after the cataloging work is completed. It is therefore my opinion that, after processing, the physical copy of the conference proceedings that contains *Kanbara* became publicly accessible at the Linda Hall Library by April 18, 2000.

31. Fields 020 show the 13-digit and 10-digit ISBNs, Field 111 shows the conference name is presented as the corporate author for this work, Field 245 shows the title, subtitles, and statement of responsibility, and Field 260 shows the publisher and copyright date. Field 500 shows “PR00478” as the IEEE Computer Society order. Number for this work. Field 504 shows this work includes bibliographic references and author index. Fields 700 shows the two editors are included and Field 710 shows the sponsor is included. Field 711 is the conference name. The MARC record shows

that when this work became discoverable in the online catalog of the Linda Hall Library on April 11, 2000, interested users could discover it by the ISBNs, conference name, title, editors, and sponsor.

32. Interested users could also conduct subject searches to discover this conference proceedings, because the MARC record contains subject representations. Field 090 shows a Library of Congress Classification number (“QA76.9.V5”) that represents “Virtual computer systems” (source: Library of Congress Classification Schedule Q at https://www.loc.gov/aba/publications/FreeLCC/LCC_Q2020TEXT.pdf), and Fields 650 show two Library of Congress subject headings, with “Human-computer interaction” and “Virtual reality” as the main topics, each followed by “Congresses” as a form subheading encoded in subfield “v” to indicate the main topics are treated at a conference.

33. The MARC record (**EX1006B**) shows that the Linda Hall Library created their original cataloging record for the conference proceedings containing *Kanbara* on April 11, 2000, making this work discoverable in their online catalog from that date on. As of that date, interested users could discover this work by the ISBNs, conference name, title, editors, and sponsor. They could also conduct subject searches to discover this work.

34. As evidence that the Linda Hall Library had an online catalog in

operation in April 2000 when the library's MARC record for the conference proceedings that contains *Kanbara* was completed, I obtained a profile of the library at <https://librarytechnology.org/library/2294> from libraries.org, a directory of libraries throughout the world. I personally located, identified, and obtained this profile. This is the type of record experts in my field would reasonably rely upon when forming their opinions. This profile is presented as **EX1006C** in this declaration.

35. The Technology Profile on page 2 of **EX1006C** shows the Linda Hall Library began using Horizon as their online catalog in 1994, and changed to Voyager in 2010. These dates mean that in April 2000 interested users were able to use the Horizon system to search for the conference proceedings containing *Kanbara* and access this article at the Linda Hall Library.

C. Copyright Registration Record

36. **EX1006D** is a true and correct copy of the copyright registration record for *IEEE Virtual Reality 2000 Proceedings* that contains *Kanbara*. I personally located, identified, and obtained this record from the public catalog of the US Copyright Office. This is the type of record experts in my field would reasonably rely upon when forming their opinions.

37. The title, subtitles, editors, imprint, and copyright claimant match the information presented in **EX1006**, confirming this record represents the conference

proceedings that contains *Kanbara*. The “Date of Publication” field shows this work was published on “2000-03-18” (*i.e.*, March 18, 2000). This date aligns well with the “4-10-00” date annotation in **EX1006** that shows the Linda Hall Library added this work to their collections on April 10, 2000. The publication date also aligns well with the library’s MARC record creation date of April 11, 2000.

D. IEEE Metadata Record

38. **EX1006E** is a true and correct copy of the metadata record for *Kanbara* from IEEE Xplore, the IEEE Digital Library. I personally located, identified, and obtained this record from <https://ieeexplore.ieee.org/abstract/document/840506>. This is the type of record experts in my field would reasonably rely upon when forming their opinions.

39. Page 1 shows the title, authors, publisher and abstract. It shows *Kanbara* was published in “Proceedings IEEE Virtual Reality 2000” whose ISBN is “0-7695-0478-7” and the conference took place on “18-22 March 2000” in New Brunswick, NJ, USA. The “Date Added to IEEE Xplore” field shows this metadata record was added to the system on “06 August 2002.” Since the general public can search IEEE Xplore free of charge, it is my opinion that *Kanbara* became publicly discoverable in IEEE Xplore on August 6, 2002. Users affiliated with institutional subscribers to this system would be able to access the full paper from this record. Users without such affiliation could use the PDF link to purchase the article online

from IEEE.

40. As evidence that IEEE Xplore was in operation in August 2002 when the metadata record for *Kanbara* was added to the system, I obtained a copy of the system's website from Internet Archive. **EX1006F** is a true and correct copy of the website of IEEE Xplore. I personally located, identified, and obtained this record. It is the type of record experts in my field would reasonably rely upon when forming their opinions.

41. Internet Archive is a digital library that archives scholarly materials, cultural artifacts, and other web resources on the Internet and provides the public with free access to its collections. I have used the Internet Archive in the past and am familiar with their practice of assigning an extended URL to an archived resource in the format of `http://www.archive.org/web/[Year in yyyy][Month in mm][Day in dd][Time code in hh:mm:ss]/[Archived URL]` to show the point of time the archived file was captured. Since Internet Archive usually does not archive web resources the moment they appear on the Internet, and a web resource must be available first before it can be archived, the archive date of a file captured by the Internet Archive is typically later than the date when the file first became publicly accessible. In other words, the archive date means the archived file was typically available before, and definitely no later than, the archive date.

42. Page 1 of **EX1006F** is a screen capture of a Wayback Machine calendar

that shows the IEEE Xplore website (<http://ieeexplore.ieee.org/lpdocs/epic03/>) was archived 115 times between “7 Apr 2000” and “2 Dec 2024” and this particular copy was archived on “FEB 07 2001” and available at <https://web.archive.org/web/20010207003457/http://ieeexplore.ieee.org/lpdocs/epic03/>. Page 2 is the PDF of this archived copy that explains that “IEEE Xplore provides full-text access to IEEE transactions, journals, magazines and conference proceedings published since 1988 and all current IEEE standards.” Under “Free to All,” the archived copy shows the general public can have “[a]ccess to tables of contents of IEEE transactions, journals, magazines, conference proceedings and standards.” The archived copy also explains that users affiliated with corporate, government and university subscribers “can search and access abstract/citation records, and full-text documents of the IEEE online publications to which” the institutions subscribe.

43. **EX1006F** informs my opinion that IEEE Xplore was available to the general public for searching by February 7, 2001, and since then individual subscribers and users affiliated with institutional subscribers to this system have been able to access full text of documents freely. Non-subscribers would have been able to purchase the full text of documents after they have identified abstract/citation records in IEEE Xplore.

E. Usage Records

44. Actual usage of a publication is reflected by other publications that make reference to it. I have reviewed citations to *Kanbara* on Google Scholar to compile a list of early citations. **EX1006G** presents five citations from 2000 to 2002 that cited this article. **EX1006G** shows the earliest citation appeared in October 2000, supporting my opinion that this article was publicly accessible at the Linda Hall Library by April 18, 2000.

F. Summary of My Opinion on *Kanbara*

45. The copyright registration record for the conference proceedings that contains *Kanbara* (**EX1006D**) shows this work was published on March 18, 2000. The date annotation on **EX1006** shows Linda Hall Library added this work to their collections on April 10, 2000, and the MARC record (**EX1006B**) shows their cataloging record was completed on April 11, 2000, making this work discoverable in their online catalog of the Linda Hall Library from that date on. The physical copy of the conference proceedings, after processing, would become publicly accessible at this library by April 18, 2000.

46. IEEE metadata record (**EX1006E**) shows *Kanbara* became discoverable in IEEE Xplore on August 6, 2002, and interested users affiliated with institutions that subscribed to IEEE Xplore would be able to access the full text of this article from the metadata record. Interested users not affiliated with institutional

subscribers would be able to use the PDF link in the record to purchase this article online from IEEE.

47. Based on the records and documents that I have reviewed and analyzed, it is my opinion that *IEEE Virtual Reality 2000 Proceedings* that contains *Kanbara* was publicly discoverable at the Linda Hall Library on April 11, 2000, when the MARC record was created. The physical copy, after processing, would become publicly accessible by April 18, 2000. *Kanbara* became discoverable and accessible on the Internet on August 6, 2002, when the metadata record for this article was added to IEEE Xplore. Citation history (**EX1006G**) shows the earliest citation to *Kanbara* appeared in October 2000, and at least five citations were published before the metadata record was added to IEEE Xplore on August 6, 2002.

IV. Conclusion

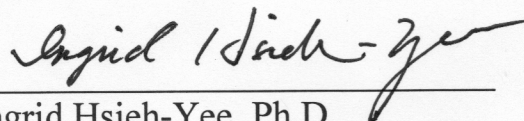
48. In signing this Declaration, I recognize that the Declaration will be filed as evidence in a contested case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I also recognize that I may be subject to cross-examination in this proceeding. If required, I will appear for cross-examination at the appropriate time.

49. I hereby declare that all statements made herein of my own knowledge are true and that all statements are 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 18 U.S.C. § 1001.

Dated: March 27, 2025

Respectfully submitted,

A handwritten signature in black ink, appearing to read "Ingrid Hsieh-Yee", written over a horizontal line.

Ingrid Hsieh-Yee, Ph.D.
Annapolis, Maryland

APPENDIX A

Ingrid Hsieh-Yee
Professor Emerita
Dept. of Library and Information Science
Catholic University of America
Washington, D.C. 20064
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Education

Ph.D. 1990. Library and Information Studies, University of Wisconsin-Madison
Minors: Sociology and Psychology

M.A. 1984. Library and Information Studies, University of Wisconsin-Madison.

M.A. 1983. Comparative Literature, University of Wisconsin-Madison.

B.A. 1980. Foreign Languages and Literature, National Taiwan University.

Work Experience

Professor, School/Dept. of Library and Information Science, Catholic University of America,
1990-2022 (Assistant Professor, 1990-1996; Associate Professor, 1997-2004; Professor
2004-2022; Professor Emerita 2022)

Co-Chair, Dept. of Library and Information Science, Catholic University of America, June 2015-
August 2016.

Acting Dean, School of Library and Information Science, Catholic University of America,
January 2010-June 2012.

Cataloger, Dept. of Legislative Reference Library, Annapolis, Maryland, 1989-1990.

Lecturer, School of Library and Information Studies, University of Wisconsin-Madison, 1988.

Teaching Assistant, School of Library and Information Studies, University of Wisconsin-
Madison, 1986-1988.

Cataloger, Health Sciences Library, University of Wisconsin-Madison, 1984-1986.

Areas of Teaching and Research Interests

Information Organization and Access; Metadata; Cataloging & Classification; Information
Architecture; Information Retrieval; Digital Collections; Social Media; Scholarly

Communication; Information Behavior; Health Informatics; Human Computer Interaction; Usability Studies

Grants & Honors

Cultural Heritage Information Management Project. IMLS grant. Amount: \$498,741. Period: Aug. 2012 to July 2015. Co-PI with Dr. Youngok Choi.

D.C. Health Information Technology (HIT4): Building Capacity & Providing Access in Our Nation's Capital. Dept. of Labor H2B Training Grant. Grant amount: \$4,175,500. Grant period: Nov. 2011 to Dec. 2015. Partner with the Metropolitan School of Professional Studies of the Catholic University of America, Children's National Medical Center, D.C. Department of Employment Services, Holy Cross Hospital, Howard University, Center for Urban Progress, Providence Hospital, and Sibley Memorial Hospital.

Capital Health Careers Project. Department of Labor Healthcare Sector and Other High Growth and Emerging Industries Grant. Grant amount: \$4,953,999. Grant period: March 2010 – February 2013. Awarded to a group of healthcare organizations and educational institutions in Washington, D.C. Providence Health Foundation of Providence Hospital (Lead institution). Part of the grant supported the development of a Master's degree program in Information Technology with a concentration in Health Information Technology offered by the School of Library and Information Science.

The Washington D.C. School Librarians Project. IMLS grant. Grant amount: \$412,660. Grant period: Aug. 2007 – June 2011. The School partnered with the District of Columbia Public Schools (DCPS) and the District of Columbia Library Association to educate and mentor school media specialists for the DCPS system. PI, Jan. 2010 to June 2011.

SIG Member of the Year, American Society for Information Science and Technology (2009).

Most Outstanding Paper of *OCLC Systems & Services* (2001).

ALISE Research Grant (2001).

Most Outstanding Paper of *OCLC Systems & Services* (2000).

Research Grant from ERIC (1999-2000).

Best Research Paper Award; Association for Library and Information Science Education (1998).

Research Grants, Catholic University of America. 1991, 1992, 1993, 1996, 1998, 1999, 2004, 2005, 2006, 2007, 2013-14.

Cooperative Faculty Research Grant, Consortium of Universities in the Washington Metropolitan Area (1993-1994).

Cooperative Research Grant, Council on Library Resources (1993-1994).

Journal of the American Society for Information Science Best Paper Award (1993).

ASIS/ISI Information Science Doctoral Dissertation Scholarship (1989).

HEA Title IIB Fellowship (Dept. of Education) (1989)

Chinese-American Librarians Association Scholarship (1987).

Beta Phi Mu (1985).

Vilas Fellowship, University of Wisconsin-Madison. 1984

Publications

Hsieh-Yee, I. (2021). Can We Trust Social Media? *Internet Reference Services Quarterly*, 1-15.
Published online: 28 July, 2021. 10.1080/10875301.2021.1947433.

Bailey, T., & Hsieh-Yee, I. (2020). Combating the Sharing of False Information: History, Framework & Literacy Strategies, *Internet Reference Services Quarterly*, 24 (1-2), 9-30.

Choi, Y., and Hsieh-Yee, I. (2010). Finding Images in an OPAC: Analysis of User Queries, Subject Headings, and Description Notes. *Canadian Journal of Information and Library Science*, 34(3): 271 – 295.

Hsieh-Yee, I. (2008). Educating Cataloging Professionals in a Changing Information Environment. *Journal of Education for Library and Information Science*, 46(2): 93-106.

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NISO Framework for Guidelines for Building Good Digital Collections. 3rd ed. Baltimore, MD: National Information Standards Organization, 2007. Also available online: <http://www.niso.org/framework/framework3.pdf> (NISO Working Group members: Priscilla Caplan (chair), Grace Agnew, Murtha Baca, Tony Gill, Carl Fleischhauer, Ingrid Hsieh-Yee, Jill Koelling, and Christie Stephenson.)

Choi, Y., Hsieh-Yee, I., and Kules, B. (2007). Retrieval Effectiveness of TOC and LCSH. *Proceedings of the Joint Conference on Digital Libraries*, pp. 233-234.

Vellucci, S., and Hsieh-Yee, I. (2007). They Didn't Teach Me That in Library School! Building

a Digital Teaching Commons to Enhance Metadata Teaching, Learning and Research. *Proceedings of the National Conference of the Association of College and Research Libraries, Baltimore, MD*, pp. 26-31.

Mitchell, Vanessa, and Ingrid Hsieh-Yee. (2007). Converting Ulrich's Subject Headings to FAST Headings: A Feasibility Study. *Cataloging & Classification Quarterly*, 45(1): 59-85.

Hsieh-Yee, I., Tang, R., and Zhang, S. (2007). User Perceptions of a Federated Search System. *IEEE Technical Committee on Digital Libraries Bulletin*, Summer 3(2) (URL = <http://www.ieee-tcdl.org>).

Tang, R., Hsieh-Yee, I., and Zhang, S. (2007). User Perceptions of MetaLib Combined Search: An Investigation of How Users Make Sense of Federated Searching." *Internet Reference Services Quarterly*, 12(12): 211-236.

Hsieh-Yee, I., Tang, R., and Zhang, S. (2006). User Perceptions of a Federated Search System. *Proceedings of the Joint Conference on Digital Libraries, June 11-15, 2006, Chapel Hill*, p. 338.

Hsieh-Yee, I. (2006). *Organizing Audiovisual and Electronic Resources for Access: A Cataloging Guide*. 2nd ed. Westport, Conn.: Libraries Unlimited.

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Hsieh-Yee, I. (2004). Cataloging and Metadata Education in North American LIS Programs. *Library Resources & Technical Services*, 48(1): 59-68.

Hsieh-Yee, I. (2004). Cataloging and Metadata Education. In Gary E. Gorman (Ed.), *International Yearbook of Library and Information Management 2003: Metadata Applications and Management*, (pp.204-234). London: Facet Publishing.

Yee, P. L., Hsieh-Yee, I., Pierce, G.R., Grome, R., and Schantz, L. (2004). Self-Evaluative Intrusive Thoughts Impede Successful Searching on the Internet. *Computers in Human Behavior*, 20(1): 85-101.

Hsieh-Yee, I. (2003). Cataloging and Metadata Education: A Proposal for Preparing Cataloging Professionals of the 21st Century. A report submitted to the ALCTS-Education Task Force in response to Action Item 5.1 of the *Bibliographic control of Web Resources: A Library of Congress Action Plan*. Approved by the Association for Library Collections and Technical Services. Web version available since April 2003 at <http://lcweb.loc.gov/catdir/bibcontrol/CatalogingandMetadataEducation.pdf>.

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- Hsieh-Yee, I., and Smith, M. (2001). The CORC Experience: Survey of Founding Libraries, Part I. *OCLC Systems & Services*, 17: 133-140. (Received "The Most Outstanding Paper of OCLC Systems & Services in 2001" award.)
- Hsieh-Yee, I., and Smith, M. (2001). The CORC Experience: Survey of Founding Libraries, Part II, Automated Tools and Usage. *OCLC Systems & Services*, 17: 166-177. (Received "The Most Outstanding Paper of OCLC Systems & Services in 2001" award.)
- Hsieh-Yee, I. (2001). ERIC User Services: Changes and Evaluation for the Future. *Government Information Quarterly*, 18: 31-42.
- Hsieh-Yee, Ingrid. (2001). Research on Web Search Behavior. *Library and Information Science Research*, 23: 167-185.
- Logan, E., and Hsieh-Yee, I. (2001). Library and Information Science Education in the Nineties. *Annual Review of Information Science and Technology*, 35: 425-477.
- Hsieh-Yee, I. (Ed.) (2001). *Library and Information Science Research*, 23 (2). A special issue in honor of the retirement of Douglas L. Zweizig.
- Hsieh-Yee, I. (2000). *ERIC User Services: Evaluation in a Decentralized Environment*. Washington, D.C.: Dept. of Education.
- Hsieh-Yee, Ingrid. (2000). *Organizing Audiovisual and Electronic Resources for Access: A Cataloging Guide*. Littleton, CO: Libraries Unlimited.
- Hsieh-Yee, I. (2000). Organizing Internet Resources: Teaching Cataloging Standards and Beyond. *OCLC Systems & Services*, 16: 130-143. (Received "The Most Outstanding Paper of OCLC Systems & Services in 2000" award.)
- Hsieh-Yee, I. (1998). The Retrieval Power of Selected Search Engines: How Well Do They Address General Reference Questions and Subject Questions? *Reference Librarian*, 60: 27-47.
- Hsieh-Yee, I. (1998). Search Tactics of Web Users in Searching for Texts, Graphics, Known Items and Subjects: A Search Simulation Study. *Reference Librarian*, 60: 61-85. (Received the 1997 Best ALISE Research Paper Award.)
- Hsieh-Yee, I. (1997). Access to OCLC and Internet Resources: LIS Educators' Views and Teaching Practices. *RQ*, 36: 569-86.

- Hsieh-Yee, I. (1997). Teaching Online and CD-ROM Resources: LIS Educators' Views and Practices. *Journal of Education for Library and Information Science*, 38: 14-34.
- Hsieh-Yee, I. (1996). The Cataloging Practices of Special Libraries and Their Relationship with OCLC. *Special Libraries*, 87: 10-20.
- Hsieh-Yee, I. (1996). Modifying Cataloging Practice and OCLC Infrastructure for Effective Organization of Internet Resources. In *Proceedings of the OCLC Internet Cataloging Colloquium*. [Online]. Available: <http://www.oclc.org/oclc/man/colloq/hsieh.htm>
- Hsieh-Yee, I. (1996). Student Use of Online Catalogs and Other Information Channels. *College & Research Libraries*, 57: 161-175.
- Hsieh-Yee, I. (1995). Ten entries in James S. C. Hu (Ed.), *Encyclopedia of Library & Information Science*, 913, 1028-29, 1036, 1037, 1145-46, 1514, 1575, 1763-64, 2216-27, 2378-79. Taipei, Taiwan: Sino-American Publishing. (Topics include "Advanced Technology/Libraries," "Information Ethics," "Instruction on Cataloging and Classification," "Instruction on Reference Services.")
- Hsieh-Yee, I. (1993). Effects of Search Experience and Subject Knowledge on Online Search Behavior: Measuring the Search Tactics of Novice and Experienced Searchers. *Journal of the American Society for Information Science*, 44: 161-174. (Received the 1993 Best JASIS Paper Award.)

Works in Progress

- Hsieh-Yee, I. Actionable lessons for debunking false information: A comparative analysis of literacy lessons in communication and library and information science
- Hsieh-Yee, I. Representing diverse voices and communities in cataloging and indexing: The evolution of controlled vocabularies
- Hsieh-Yee, I. Information Organization and Retrieval in Practice (a monograph scheduled for completion and publication in 2023)

Presentations

- Bailey, T. & Hsieh-Yee, I. (February 2020). The Phenomena of Sharing Misinformation and the Need for Information Literacy. Presented at the 2020 Bridging the Spectrum Symposium, Washington, D.C., February 14, 2020.

- Hsieh-Yee, I. and Fragan-Fly, J. (May 2018) Trends, Design & Strategies for Digital Scholarship Services. Presented at the 2018 Maryland/Delaware Library Association Conference, Cambridge, MD.
- Hsieh-Yee, I. (February, 2018) Research Data Management: What It Takes to Succeed. Presented at the 10th Bridging the Spectrum Symposium, Washington, D.C.
- Hsieh-Yee, I. (February, 2017) *Research Data Management: New Competencies and Opportunities for Information Professionals*. Presented at the 9th Bridging the Spectrum Symposium, Washington, D.C.
- Hsieh-Yee, I. and Lawton, P. (February, 2017) *Enhancing Catholic Portal Searches with User Terms and LCSH*. Presented at the 9th Bridging the Spectrum Symposium, Washington, D.C.
- Hsieh-Yee, I. (2016, October) *Visualizing Data for Information*. Presented at the 2016 Virginia Library Association Conference, Hot Springs, VA.
- Hsieh-Yee, I. (2016, August) *Religious Materials Toolbox for Archivists: Solutions to Problems Facing the Profession*. Presented at Archives * Records 2016, Atlanta, GA.
- Hsieh-Yee, I. and Lawton, P. (2016, March) *Enhancing Retrieval of Catholic Materials with LCSH Knowledge Structure*. Presented at the 2016 Catholic Library Association Conference, San Diego, CA.
- Fagan-Fry, J. and Hsieh-Yee, I. (2016, February) *Approaches to Digital Scholarship at Top Universities around the World: Scholarly Publishing in the Digital Age*. Presented at the 8th Bridging the Spectrum Symposium, Washington, D.C.
- Hsieh-Yee and Fagan-Fry, J. (2016, January) *Innovative Services for Digital Scholarship at Top 100 Research Libraries of the World*. Poster presented at the 2016 Annual Conference of the Association for Library and Information Science Education, Boston, Mass.
- Hsieh-Yee, I. and Lawton, P. (2015, June). *Crowdsourcing terms for CRRA portal themes*. Poster presented at the third CRRA symposium and annual meeting, Bringing the created toward the Creator: Liturgical art and design since Vatican II. Catholic Theological Union, Chicago, Illinois.
- Hsieh-Yee, I. and Lawton, P. (2015, February). *Crowdsourcing terms for thematic exploration in the Catholic Portal*. Poster presented at the 7th Annual Bridging the Spectrum Symposium, Washington, D.C.
- Hsieh-Yee, I., James, R., and Fagan-Fry, J. (2015, February). *Support for digital scholarship at top university libraries of the world*. Poster presented at the 7th Annual Bridging the Spectrum Symposium, Washington, D.C.

- Hsieh-Yee, I., Zhang, S., Lin, K., and Cherry, S. (2015, February). *Thus said the end users: Summon experience and support for research workflows*. Poster presented at the 7th Annual Bridging the Spectrum Symposium, Washington, D.C.
- Yontz, E., Hsieh-Yee, I., & Houston, S. (2015, February). *Healthy Heroes Summer Reading Club: Developing healthy youth at public libraries*. 11th Annual Jean Mills Health Symposium, Greenville, North Carolina.
- Yontz, E., Hsieh-Yee, I., and Houston, S. (2015, January). *Healthy youth and libraries: A pilot study*. Association for Library & Information Science Education (ALISE) Annual Conference, Chicago, Illinois.
- Hsieh-Yee, I. (2014, May). *Linking CRRRA resources to portal themes via authority files*. Presented at the Catholic Research Resources Alliance 2014 Membership Meeting, Marquette, WI.
- Hsieh-Yee, I. (2014, April). *Enhancing subject access to CRRRA resources*. Presented at the 2014 Catholic Library Association Conference, Pittsburgh, PA.
- Hsieh-Yee, I. (2014, January). *Health Information Technology Program: Educational entrepreneurship in action*. Presented at the 2014 annual Conference of the Association for Library and Information Science Education, Philadelphia, PA.
- Hsieh-Yee, I., Zhang, S., Lin, K., and Cherry, S. (2014, January). *Discovering information through Summon: An analysis of user search strategies and search success*. Paper presented at the 6th Bridging the Spectrum Symposium, Washington, D.C.
- Hsieh-Yee, I. (2012, December). *National Digital Stewardship Alliance and SLIS at CUA: An Educational Partnership*. Paper presented at Best Practices Exchange: Acquiring, Preserving, and Providing Access to Government Information in the Digital Era, Annapolis, MD.
- Choi, Y. and Hsieh-Yee, I. (2010, January). *Finding Images in an OPAC: Analysis of User Queries, Subject Headings, and Description Notes*. Paper presented at 2nd Annual Bridging the Spectrum Symposium, Catholic University of America, Washington, D.C.
- Hsieh-Yee, I. and Coogan, J. (2010, January). *Google Scholar vs. Academic Search Premier: What Libraries and Searchers Need to Know*. Paper presented at 2nd Annual Bridging the Spectrum Symposium, Catholic University of America, Washington, D.C.
- Hsieh-Yee, I. (2009, November). *Information Science Education: An LIS School's Perspective*. Paper presented at Annual Meeting of the American Society for Information Science and Technology, Vancouver, British Columbia, Canada.

- Hsieh-Yee, I., Menard, E., Ya-Ning Chen, A., Shu-Jiun Chen, S., Kalfatovic, M. R., Wisser, K. M. (2009, November). *Information Organization in Libraries, Archives and Museums: Converging Practices and Collaboration Opportunities*. Presented at Annual Meeting of the American Society for Information Science and Technology, Vancouver, British Columbia, Canada. (Organizer and moderator of this panel.)
- Hsieh-Yee, I. and Coogan, J. (2009, July). *Catching up to Google Scholar: The Retrieval Power of Academic Search Premier and Google Scholar*. Poster presented at American Library Association Conference, Chicago, Illinois.
- Hsieh-Yee, I., with the CUA Scholarly Communications Project Team. (2009, January). *Digital Scholarship@CUA: Developing an Institutional Repository for CUA*. Poster presented at 1st Annual Bridging the Spectrum Symposium, Catholic University of America, Washington, D.C.
- Wise, M., Cylke, K., and Hsieh-Yee, I. (2009, January). *Digital Talking Books: Meeting the Needs of the Blind and the Handicapped*. Paper presented at the Bridging the Spectrum Symposium, Catholic University of America, Washington, D.C.
- Hsieh-Yee, I. (2009, January). *User Expectations of MERIC*. Presented at the Information Organization Competencies for the 21st Century Discussion Session of the 2009 Conference of the Association for Library and Information Science Education, Denver, Colorado.
- Choi, Y., and Hsieh-Yee, I. (2008, November). *Subject Access for Images in an OPAC*. Annual Meeting of the American Society for Information Science and Technology, Columbus, Ohio. (Also co-organized a panel on Retrieving and Using Visual Resources: Challenges and Opportunities for Research and Education.)
- Hsieh-Yee, I. (2008, June). *Educating Cataloging Professionals in a Changing Information Environment*. National Taiwan University, Taipei, Taiwan.
- Vellucci, S. L., Moen, W.E., Hsieh-Yee, I., Marson, B., and Wisser, K. (2008, January) *Building a Metadata Education and Research Community through MERIC (Metadata Education and Research Information Commons): Demo and Stakeholder Input*. A panel presented at the 2008 Conference of the Association for Library and Information Science Education, Philadelphia, Pennsylvania.
- Hsieh-Yee, I., Choi, Y. and Kules, B. (2007, October). *Searching for Books and Images in OPAC: Effects of LCSH, TOC and Subject Domains*. A poster presented at the American Society for Information Science and Technology Annual Meeting, Milwaukee, Wisconsin.
- Hsieh-Yee, I. and Coogan, J. (2007, August) *Google Scholar vs. Academic Search Premier: A Comparative Analysis*. Presented to the Faculty and Staff of the University of the District

of Columbia.

- Hsieh-Yee, I. and Coogan, J. (2007, June). *Google Scholar vs. Academic Search Premier: A Comparative Analysis*. Presented to the Washington Research Library Consortium Community, Catholic University of America, Washington, D.C.
- Hsieh-Yee, I., Choi, Y., and Kules, B.. (2007, June). *What Users Need for Subject Access: Table of Contents or Subject Headings?* A poster presented at the 2007 American Library Association Annual Conference, Washington, D.C., June 2007.
- Choi, Y., Hsieh-Yee, I., and Kules, B. (2007, June). *Retrieval Effectiveness of TOC and LCSH*. A paper presented at the Joint Conference on Digital Libraries 2007, Vancouver, Canada.
- Vellucci, S. L., Hsieh-Yee, I., and Moen, W.E. (2007, May). *If We Build It, Will They Come? Building a Community of Practice for Metadata Stakeholders*. A poster presented at the Rutgers University Research Day, Bridgeton, New Jersey.
- Hsieh-Yee, I. (2007, May). *Federated Searching: User Experience & Perceptions*. International Conference on Information Organization & Retrieval, National Taiwan University, Taipei, Taiwan.
- Hsieh-Yee, I. (2007, May). *Search Performance of Google Scholar and Academic Search Premier*. International Conference on Information Organization & Retrieval, National Taiwan University, Taipei, Taiwan.
- Hsieh-Yee, I. (2007, May) *MERIC: Building a Digital Commons for Metadata Education & Research*. International Conference on Information Organization & Retrieval, National Taiwan University, Taipei, Taiwan.
- Hsieh-Yee, I., and Coogan, J. (2007, March/April). *A Comparative Analysis of Google Scholar and Academic Search Premier*. Poster presented at the Association of College & Research Libraries 13th National Conference, Baltimore, Maryland.
- Vellucci, S. L. and Hsieh-Yee, I. (2007, March/April) *They Didn't Teach Me That in Library School! Building a Digital Teaching Commons to Enhance Metadata Teaching, Learning and Research*. On-site presentation and Webcast by Elluminate. A contributed paper presented at the Association of College & Research Libraries 13th National Conference, Baltimore, Maryland. The acceptance rate for contributed paper was 20%. This paper was one of 10 conference papers chosen for live webcast during the conference.
- Moen, W., Hsieh-Yee, I. and Vellucci, S.L. (2007, January) *A DSpace Foundation for a Teaching & Research Commons: The Metadata Education and Research Information Commons*. A poster session presented at the Open Repositories Conference 2007, San Antonio, Texas.

- Tang, R., Hsieh-Yee, I., and Zhang, S. (2006, November) *User Perception of MetaLib Combined Search*. Paper presented at the Annual Meeting of the American Society for Information Science and Technology, Austin, Texas, Nov. 2006.
- Hsieh-Yee, I. (2006, November). *Federated Searching: User Perceptions, System Design, and Library Instructions*. Paper presented at the Annual Meeting of the American Society for Information Science and Technology, Austin, Texas. (Panel organizer, moderator, presenter).
- Hsieh-Yee, I. (2006, November). *Building a Digital Teaching Commons to Enhance Teaching and Learning: The MERIC Experience and Challenges*. Paper presented at the Annual Meeting of the American Society for Information Science and Technology, Austin, Texas. (Panel organizer, moderator, presenter)
- Hsieh-Yee, I. (2006, September). *Search Performance of Google Scholar and Academic Search Premier*. Paper presented at the ERIC Publishers Meeting, Washington, D.C.
- Hsieh-Yee, I., Zhang, S., and Rong Tang, R. (2006, June). *User Perceptions of a Federated Search System*. Poster presented at Joint Conference on Digital Libraries, Chapel Hill, North Carolina.
- Hsieh-Yee, I. and Zhang, S. (2006, June). *Preparing Users for Federated Search: Implications of a MetaLib User Perceptions Study*. Paper presented at the 2006 Ex Libris User Groups of North America Conference, Knoxville, Tennessee.
- Hsieh-Yee, I. (2006, January). *MERIC Organizations and Navigation*. Paper presented at the 2006 ALISE Annual Conference, San Antonio, Texas.
- Hsieh-Yee, I. (2006, January). *Metadata and Cataloging Education: Recommended Competencies*. Paper presented at the 2006 ALISE Annual Conference, San Antonio, Texas.
- Hsieh-Yee, I. (2005, November). *Digital Library Evaluation: Progress & Next Steps*. Presentation at the Annual Meeting of the American Society for Information Science & Technology, Charlotte, North Carolina.
- Hsieh-Yee, I. (2005, August). *Providing Access to Digital Content: Issues for DL Managers*. Presentation at MDK12 Digital Library Steering Committee Meeting, Columbia, Maryland.
- Hsieh-Yee, I. (2005, April). *Enhancing Teaching and Learning: The Role of School Library Media Specialists*. Presentation at Meeting of the Baltimore County Public School System School Media Specialists, Baltimore, Maryland.

- Hsieh-Yee, I. (2005, January). *Subject Access and Users: Insights & Inspirations from Marcia J. Bates*. Paper presented at the Historical Perspectives SIG, 2005 Conference of the Association for Library and Information Science Education, Boston, Massachusetts.
- Hsieh-Yee, I. (2005, January). *Electronic Resource Management: Practice, Employer Expectations, & CE Interests*. Paper presented at Technical Services Education SIG, 2005 Conference of the Association for Library and Information Science Education, Boston, Massachusetts.
- Hsieh-Yee, I. (2004, October). *Library Professionals for the Digital Age: Competencies & Preparation*. Paper presented at Bibliographic Access Management Team meeting, Library of Congress, Washington, D.C.
- Hsieh-Yee, I. (2004, January). *Cataloging and metadata expertise for the digital era*. Presented at Preparing 21st Century Cataloging and Metadata Professionals: A Workshop for Educators and Trainers, San Diego and sponsored by ALCTS, ALISE, LC, and OCLC.
- Hsieh-Yee, I. (2004, January). *Educating catalogers for the digital era*. Paper presented at the Technical Services SIG, 2004 Conference of the Association for Library and Information Science Education, San Diego.
- Hsieh-Yee, I. (2003, July). *Cataloging Education for the 21st Century*. A presentation at the Library of Congress, Washington, D.C.
- Hsieh-Yee, I. (2002, January) *Metadata Education and Research Priorities: A Delphi Study of Metadata Experts*. Presentation at the 2002 Conference of the Association for Library and Information Science Education, New Orleans.
- Hsieh-Yee, I. (2001, November). *A Delphi Study of Metadata: Preliminary Findings*. Poster session at the 2001 Annual Meeting of the American Society for Information Science & Technology, Washington, D.C.
- Hsieh-Yee, I. (2001, June). *Resources on Asian American Children: Analysis of Retrieval by Search Engines and WorldCat*. Presentation at the National Conference on Asian Pacific American Librarians, San Francisco.
- Hsieh-Yee, I. (2001, January). *Delphi Study on Metadata: Project Design*. Presentation at Research Awards Session, Association for Library & Information Science Education, Washington, D.C.
- Hsieh-Yee, I. (2000, May). *Web Search Behavior Research: Progress and Implications*. Presentation at the Symposium on Evaluating Library and Information Science Research, University of Wisconsin-Madison, Madison, Wisconsin.

- Hsieh-Yee, I. (2000, March). *ERIC User Services: Evaluation in a Decentralized Environment*. Presentation at the National ERIC Joint Directors/Technical Meeting, Arlington, Virginia.
- Hsieh-Yee, I. (2000, January). *Enhancing Learning with Web Technology*. Presentation at Faculty Conversations, Catholic University of America, Washington, D.C.
- Hsieh-Yee, I. (2000, January). *From Surrogates to Objects: CUA's Approaches to Organizing Electronic Resources*. Paper presentation at the Annual Conference of the Association for Library and Information Science Education, San Antonio, Texas.
- Yee, P., and Hsieh-Yee, I. (1997, November). *Individual Differences in Search Behavior on the WWW*. A poster session presented at the 38th Annual Meeting of the Psychonomic Society, Philadelphia, Pennsylvania.
- Hsieh-Yee, I. (1997, April). *Research + Marketing + Preparation = Job!* Presented at the "Workshop on Resume and Interview Techniques," Special Libraries Association, Student Chapter, Catholic University of America, Washington, D.C.
- Hsieh-Yee, I. (1997, February). *Creating CyberCatalogers: Education and Training*. Presentation at ALA's Midwinter Meeting, Washington, D.C.
- Hsieh-Yee, I. (1997, February). *Search Tactics of Web Users in Searching for Texts, Graphics, Known Items and Subjects: A Search Simulation Study*. Presented at the Conference of the Association for Library and Information Science Education, Washington, D.C.
- Hsieh-Yee, Ingrid. "Beginning Your Special Library/Information Center Career." Presented at SLA's "Career Day," Jan. 11, 1997, Catholic University of America.
- Hsieh-Yee, I. (1996, September). *The Roles of Library and Information Scientists in Managing Electronic Information*. Presentation at Hamilton College, Clinton, New York.
- Hsieh-Yee, I. (1996, May). *The Future of Cataloging as a Profession*. Presented at "The Cataloging Forum, Library of Congress, Washington, D.C.
- Hsieh-Yee, I. (1994, October). *The Impact of the Internet on OPACs*. Presented at the Third Workshop on User Interfaces for OPACs, Library of Congress, Washington, D.C.

Reports

- Hsieh-Yee, I., with Knowledge Management Competencies and Performance Action Group of the Federal Knowledge Management Initiative. "From Knowledge Management Competencies to Improved Organizational Performance." April 9, 2009.

Hsieh-Yee, I., with Knowledge Practices Action Group of the Federal Knowledge Management Initiative. "KM Practice in Government Agencies: Findings and Recommendations." April 9, 2009.

Hsieh-Yee, I. "Delphi Study on Metadata." 2001. Three quarterly reports submitted to the Association for Library and Information Science Education.

Hsieh-Yee, I. "College Students' Information Channels: Patterns of Use and Possible Factors in Channel Selection." 1995. Submitted to the Catholic University of America.

Hsieh-Yee, I. "The Information-Seeking Patterns of Scholars and Their Use of an Online Information System." 1994. Submitted to the Council on Library Resources.

Book Reviews

Review of *The Measurement and Evaluation of Library Services*, by Sharon L. Baker and F. Wilfrid Lancaster. *Information Processing and Management* 30 (1994): 450-52.

Review of *Subject Access to Films and Videos*, by Sheila S. Intner and William E. Studwell; and *Cataloging Unpublished Nonprint Materials*, by Verna Urbanski with Bao Chu Chang and Bernard L. Karon. *Information Processing and Management* 30 (1994): 449-50.

Review of *Automated Information Retrieval in Libraries: A Management Handbook*, by Vicki Anders. *Journal of Library and Information Science* 19 (1993): 98-100.

Review of *Full Text Databases*, by Carol Tenopir and Jung Soon Ro. *Information Processing and Management* 28 (1992): 667-68.

Review of *Descriptive Cataloging for the AACR2R And USMARC: A How-to-Do It Workbook*, by Larry Millsap and Terry Ellen Ferl. *Information Processing and Management* 28 (1992): 809-11.

Review of *MARC Manual: Understanding and Using MARC Records*, by Deborah J. Byrne. *Information Processing and Management* 28 (1992): 537-38.

Service

Professional Associations and Societies

- Library of Congress. RDA Training Program for the Profession. Co-authored with Tim Carlton. 2013-2014.
- 2014 Digital Preservation Outreach & Education Survey. Contributed to the design of the survey, 2014.
- National Digital Stewardship Alliance. Outreach Committee. 2011-2014.
- National Digital Stewardship Residency Program. Advisory Group, 2012-2013.
- FEDLINK Health Information Technology Advisory Council, 2011-2015.

- 2012 Joint Conference on Digital Libraries. Program Planning Committee, Pre-Conference Proposals Review Committee, 2012
- Catholic Research Resources Alliance. Five-Year Strategic Plan Task Force, 2011-2012
- Institute of Museum and Library Services. Grant reviewer. 2004, 2005, 2010.
- Association for Library and Information Science Education.
 - * ALISE Bodan Wynar Research Paper Award Committee, 2015, 2016, 2017
 - * ALISE Eugene Garfield Dissertation Award Competition, Jury, 2013, 2014
 - * ALISE Research Grant Competition Committee. Chair, 2012
 - * Pratt-Severn Faculty Innovation Award. Chair, 2009, 2010
 - * ALISE Doctoral Poster Jury, 2012
 - * “Information Organization Competencies for the 21st Century” Discussion session leader. 2009 Conference of the Association for Library and Information Science Education.
 - * Assisted Technical Services SIG Convener in organizing a program, “Building a Metadata Education and Research Community through MERIC (Metadata Education and Research Information Commons): Demo and Stakeholder Input” for the 2008 ALISE conference.
 - * Association for Library Collections and Technical Services/Association for Library and Information Science Education (ALCTS/ALISE) Metadata Education and Research Information Center (MERIC) Advisory Board, Co-Chair (with Sherry Vellucci), 2005-2007. Chair, 2008-2009 (leading the effort to build MERIC, a repository and collaborative space for metadata educators, practitioners, and researchers)
 - * Technical Services SIG, Convener, 2004-2005. Organized a program on “Electronic Resources Management: Current Practices, Employer Expectations, and Teaching Strategies” for the 2005 conference in Boston, Massachusetts.
 - * Technical Services SIG, Convener, 2003-2004. Organized a program on “Organizing Information with Metadata: Desired Competencies and Teaching Innovations” for the 2004 conference.
 - * Technical Services SIG, Convener, 1999-2000. Organized a program on "Teaching the Organization of Electronic Resources" for the 2000 conference.
 - * Curriculum SIG, Co-convener (with Sibyl Moses), 1996-97. Organized a program on “Government Information Policy” for the 1997 conference.
- American Society for Information Science & Technology.
 - * Reviewer, Conference program panel submissions and poster submissions, 2005, 2006, 2007, 2009, 2011, 2012, 2013, 2014, 2015, 2016, 2017
 - * Nomination Committee, 2009-2011
 - * Information Science Education Special Interest Group. American Society for Information Science and Technology. Chair-Elect, 2007-2008. Chair 2008-2009.
 - * Committee on Information Science Education. 1999-2006.
 - * Committee on Information Science Education. Organizing Committee for an orientation program for students at ASIS annual meetings, 1999-2001
 - * Committee on Information Science Education. Sub-committee on Student Welfare (focusing on issues related to master's education), 1998-2001

- * SIG ED. Organizing Committee for the "Seminar on Research and Career Development" for junior researchers. 1995-96 (chair), 1997-2001
- * ISI Doctoral Dissertation Proposal Scholarship Jury, 1997; 2001, 2002
- * Pratt-Severn Best Student Research Paper Award Jury. Chair. 1997
- * 1998 Midyear Meeting (referee of contributed papers), 1997
- * Organizer and moderator of the ASIS Doctoral Forum and the Doctoral Research Seminar 1994-1995
- * SIG Human Computer Interaction. Chair-Elect, Chair, 1993-1995
- * Doctoral Forum Award Jury, 1995
- * Best Student Paper Award Jury, 1995
- American Library Association.
 - * Committee on Accreditation, External Review Panelist, 2009- (site visiting team 2013-2014; site visiting team 2016-2017)
 - * Association for Library Collections and Technical Services Task Force on Competencies and Education for a Career in Cataloging, member, 2008-2009
 - * Facilitator for "What They Don't Teach in Library School: Competencies, Education and Employer Expectations for a Career in Cataloging," an Association for Library Collections and Technical Services Preconference, June 22, 2007 in Washington, D.C. Also a local liaison for bringing this program to the Catholic University of America.
 - * Facilitator for a discussion on "Effect of Electronic Resources on Technical Services" at ALA's Midwinter Meeting held in Feb. 1997 in Washington, D.C.
 - * International Relations Committee, Subcommittee Task Force for IFLA and China, 1994-1997
- Virginia Association of School Librarians. Scholarships and Awards Committee. 2010-2012
- Federal Knowledge Management Initiative, Knowledge Management Practices Action Group. Member. 2009 (leading the effort to build a knowledge management repository)
- Federal Knowledge Management Initiative, Knowledge Management Competencies & Learning Action Group. Member. 2009 (developing an action plan for helping government knowledge workers and government agencies to develop knowledge management competencies)
- National Center for Education Statistics. Technical Review Panel. 2008.
- External evaluator for a case of promotion to full professorship. University of Tennessee. 2008.
- National Information Standards Organization (NISO). Advisory Board, Revision of "IMLS Framework of Guidance for Building Good Digital Collections," 2004, 2007.
- Library of Congress, Bibliographic Control of Web Resources: A Library of Congress Action Plan. Principal Investigator of Action Item 5.1, focusing on cataloging and metadata education for students and new librarians, 2002-2003. (worked with the Association for Library Collections and Technical Services, Education Task Force)

- Chinese American Librarians Association
 - * Chinese American Librarians Association Outstanding Library Leadership Award in Memory of Dr. Margaret Chang Fung, Award Committee, 2016-2017
 - * Achievement Award Jury, 2000-2001
 - * CALA Goal 2000 Task Force, 1997
 - * Scholarship Committee, 1995, 1996-1997 (chair)
 - * Board of Directors, 1994-1997
 - * Publication Committee, 1993-1995
 - * International Relations Committee, 1993-1996
- SailorSM Assessment Advisory Group (An impact study of Sailor, Maryland's Public Information Network), 1995
- Editorial boards
 - Journal of Library & Information Science. Editorial Board, 2012-
 - Chinese American Librarians Association, *Occasional Papers Series*. Editorial Board, 2009-2016.
 - Library Quarterly*. Editorial Board, 2003-2008
 - Bulletin of the Medical Library Association*, 1994-97
 - Newsletter editor for the Chinese American Librarians Association, 1989-92
- Referee for the following journals
 - Information Processing and Management*
 - Journal of Digital Information*
 - Journal of Education for Library and Information Science*
 - Journal of Information Science*
 - Journal of Library & Information Science*
 - Journal of Library Metadata*
 - Journal of the American Society for Information Science & Technology*
 - Library and Information Science Research*
 - Library Quarterly*
- Expert reviewer, “Digital Library” course, Evaluation module, University of North Carolina, Chapel Hill, 2007-2008.
- Expert reviewer, “Information Organization” course, University of Michigan, Ann Arbor. 2007.

Catholic University of America

- Academic Senate Committee on Appointments and Promotions, 2005-2008
- Academic Senate Committee on Committees and Rules, 2009-2012, 2019-2022
- Academic Senate representative (for School of Arts & Sciences), 2017-2020

- Academic Senate representative (for School of Library & Information Science) 2003-2012
- Academic Senate Library Committee, Interim Chair (2007), Member, 2008-2012
- Academic Senate Committee on Computing, 1995-2003
- President's Administrative Council, 2010-2012
- Deans' Council, 2010-2012
- Academic Leadership Group, 2010-2012
- Graduate Board, 2010-2012
- School of Arts & Sciences, Committee on Appointments and Promotions, 2015-2019
- School of Arts & Sciences, Academic Council, 2015-2016.
- School of Arts & Sciences, Ordinary Professor Group, 2013-
- Doctoral Dissertation Defense Committee, Chair, Dept. of Psychology, 2016, 2017, 2018, 2019, 2020, 2021, 2022
- Doctoral Dissertation Defense Committee, Chair, Dept. of Education, 2014, 2015, 2017, 2018, 2019
- Doctoral Dissertation Defense Committee, Chair, National Catholic School of Social Services, 2019, 2020, 2021
- Doctoral Dissertation Defense Committee, Chair, School of Nursing, 2006, 2008
- CUA Scholarly Communication Project Team, Member (2007), Chair, 2008-2009
- Dean Search Committee, 1992-1994, 1998-1999, 2002-2003, 2006-2007
- Fulbright Review Panel, 2006
- CUA Service Learning Advisory Board, 2001-2002
- CUA Faculty Conversations on Enhancing Teaching and Learning through Technology, Planning Group, 1999-2001
- CUA Initiative on Technology and Teaching, 1998-2001

Dept. of Library and Information Science

- Admissions Committee, 2007-2009, Chair 2010-2012, Member 2013-2015, Member 2018-2022
- Appointments and Promotions Committee, 1991-2022
- Student advisement, 1990-2022
- 4+1 Bachelor to Master program, Program Advisor, 2014-2022
- LIS Minor, Advisor, 2017-2022
- Curriculum Committee, 2020-21 (Member), 2021-2022 (Chair)
- Scholarship & Awards Committee, 2016-2018, 2020-21
- Comprehensive examination editor, 2020-21
- Symposium, Colloquium, Lecture Series Committee, May 2018-May 2020 (Chair)
- Symposium and Colloquium Committee, fall 2016-May 2018
- Bridging the Spectrum Symposium session moderator, 2018, 2019, 2020, 2021

- Organization of Information Core Course Outcomes Assessment, 2019, 2020
- The Information Professions in Society Core Course Outcomes Assessment, 2019, 2020
- Community Services Librarianship, Course of Study Review and Revision, 2020
- Organization of Information, Course of Study Review and Revision, 2019
- Organization of Information, Competency and Course Offerings Review, 2018-2019
- Accreditation presentation, Chair, June 2015-August 2016
- Interim Co-Chair, June 2015-August 2016.
- Blended/OWL Learning Committee, spring 2016-2018
- Technology Committee, fall 2016-2017
- Comprehensive examination editor, 2016-2017, reader (every year since 1990)
- LIS Advisory Board, 2015-2016 (chair); fall 2016- May 2018 (member)
- Committee on Planning and Assessment, 2015-2016 (chair)
- Senior Faculty Committee, 2014-2016.
- Accreditation Steering Committee, 2014-2016 (Chair, 2015-2016)
- Accreditation Students Standard Committee, co-chair, 2014-2016
- Accreditation Mission, Goals, and Objectives Standard Committee, co-chair, 2014-2016
- Accreditation Curriculum Standard, member 2014-2-16
- Accreditation Administration and Finance Standard, member 2014-2016
- Cultural Heritage Information Management Project (IMLS-funded), Co-PI, 2012-2015
- Cultural Heritage Information Management Forum (scheduled for June 2015), Co-Organizer, 2013-2015
- Health Information Technology Interim Review Committee, 2015 (chair)
- Health Sciences Librarianship Advisory Group, 2015- (chair)
- Comprehensive examination editors, 2013-2014, 2016-2017
- National Digital Stewardship Alliance liaison, 2011-2014
- Advisory Board, Chair 2010-2012
- Academic Honesty Committee, Chair, 2008-2012
- Blended Learning Committee, 2010-2012
- Colloquium Committee, 2010-2012
- Comprehensive Examination Administration, 2010-2012
- Cultural Heritage Information Management Advisory Committee, 2010-2012 (chair), 2013-
- Curriculum Committee, 1991-2003, 2007-2009, Chair 2010-2012, member 2013-
- Curriculum Subcommittee on Comprehensive Examination, Chair 2009-2012
- Health Information Technology Advisory Board, Chair 2010-2012. Member 2013-
- Health Sciences Advisory Committee, 2009, Chair 2010-2012. Member 2013-
- HIT Expert Forum, Chair 2012. Member 2013-2015
- Health Information Technology Student Group Advisor, 2011-2012
- State Council for Higher Education of Virginia, SLIS Representative, 2010-2012
- Symposium Planning Committee, 2010-2012
- Website Management Team, Chair, 2010-2012
- Urban School Librarianship Project (IMLS-Funded), PI, 2007-2011 (chair, 2010-11)

- Failing Grades Committee, 1995-1997 (chair), 2000-2001 (chair), 2004-2005 (chair), 2007 (chair)-2011
- Faculty Search Committee, 1994-1998, 2002-2004, 2006 (chair), Fall 2007-2009, Chair fall 2009-2012
- Recruitment Committee, Chair 2010-2012
- Strategic Planning Committee, Chair 2010-2012
- Technology Committee, 2010-2012
- Accreditation Advisory Committee, 2007-2009
- Accreditation Coordinating Committee, 2007-2009
- Accreditation Steering Committee, 2007-2009
- SLIS Advisory Group, 2007-2009
- Accreditation Curriculum Standard Committee, Co-chair, 2007-2009
- Accreditation Faculty Standard Committee, Co-chair, 2007-2009
- LSC 551 Information Organization Review Team, Co-chair, 2008-2009, 2015-2016.
- Curriculum Subcommittee on Portfolios, 2009
- LSC 555 Information Systems in Libraries and Information Centers Review Team, contributor, 2008-2009
- Redesign of LSC 730 Use and Users of Libraries and Information. 2009-
- Development of a metadata institute that was taught as LSC 715 Organization of Internet Resources in 2008. The institute is being revised and will be offered in 2010 under a new course title.
- Development of lesson plans, assignments, and evaluation rubrics for LSC 606, Cataloging and Classification, for the School's NCATE accreditation. 2008
- Howard and Mathilde Rovelstad Scholarship Committee, Chair, 2004-2007
- Assistant Dean Search Committee, Chair, Fall 2007
- Liaison to the Association for Library Collections and Technical Services to bring its preconference program, Cataloging Education and Employer Expectations, to CUA during the 2007 American Library Association Annual Meeting in Washington, D.C.
- Organizer of the colloquium presentation and reception for Tamar Sadeh of Ex Libris on PRIMO June 2007
- Practicum review and design (work with potential supervisors, such as the American Indian Museum internship description revision) 2006-
- Comprehensive examinations (edits, proctoring, and grading), 1990-
- SLIS Web site redesign: Comments and suggestions. Fall 2007
- Conducted surveys of current students and alumni in preparation for the 2005 re-accreditation, 2004-2005
- Technology Committee, 1992-1999 (chair, 1996-1998), 2002-2003 (member)
- Colloquia Committee 1997-1999, 2002-2003.
- Advisor of the CUA Student Chapter of the American Society for Information Science and Technology, 2002-2003
- Visiting Professor Search Committee, 1999, 2000, 2001
- Leader, Participation in the CORC experiment, 1999-2000
- Advisor of the Special Libraries Association Student Chapter, 1993-1999; the group was recognized for outstanding leadership by SLA in 1999.

- COA planning Committee, Task Force on Electronic Presentation of SLIS Reports (team leader) 1997-1998
- COA Planning Committee, Subcommittee on Technology 1996-1998
- NLM practicum coordinator, 1997-1998
- Computer Literacy Workshops: Assisted with the development and evaluation of the workshops, 1996-1998
- Leader, Participation in the InterCat project, 1995-1997

APPENDIX B

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MARC 21 Reference Materials

[Part VII: A Summary of Commonly Used MARC 21 Fields](#)

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Part VII:

A Summary of Commonly Used MARC 21 Fields

This is a summary of the MARC 21 tags used most frequently by libraries in entering their own bibliographic records. For full listings of all MARC 21 tags, indicators, and subfield codes, see *MARC 21 Format for Bibliographic Data*.

In the explanations on these pages:

Tags -- The tags (3-digit numbers) are followed by the names of the fields they represent. In this summary, and in the *MARC 21 Format for Bibliographic Data*, if a tag can appear more than once in one bibliographic record, it is labeled repeatable (R). If it can only be used once, it is labeled non-repeatable (NR). For example, a catalog record can have several subjects, so the tags for subject added entries (6XX) are labeled repeatable (R).

Indicators -- The use of indicators is explained in fields where they are used. Indicators are one-digit numbers. Beginning with the 010 field, in every field -- following the tag -- are two character positions, one for Indicator 1 and one for Indicator 2. The indicators are not actually defined in all fields, however. And it is possible that a 2nd indicator will be used, while the 1st indicator remains undefined (or vice versa). When an indicator is undefined, the character position will be represented by the character # (for blank space).

Subfield codes -- All the data in each field (beginning with the 010 field) is divided into subfields, each of which is preceded by a delimiter-subfield code combination. The most common subfield codes used with each tag are shown. Each subfield code is preceded by the character \$, signifying a delimiter. The name of the subfield follows the code.

In general, every field **MUST** have a subfield 'a' (**\$a**). One exception that is often seen is in Field 020 (ISBN), when the ISBN information (subfield **\$a**) is unavailable but the price (subfield **\$c**) is known. Some subfields are repeatable. In this summary, repeatability is noted for only the more common repeatable subfields.

Examples: Examples follow the explanation for each field. For clarity, one space has been placed between the tag and the first indicator, one space has been placed between the second indicator and the first delimiter- subfield code, and one space has been inserted between the delimiter-subfield code and the subfield data.

010 Library of Congress Control Number -- (LCCN)

(NR, or Not Repeatable)

*Indicators undefined.**Subfield used most often:***\$a** -- Library of Congress control number

Example: 010 ## \$a ###86000988#

020 International Standard Book Number -- (ISBN)

(R, or Repeatable)

*Indicators undefined.**Subfields used most often:***\$a** -- International Standard Book Number**\$c** -- Terms of availability (often a price)**\$z** -- Cancelled/invalid ISBN (R)

Example: 020 ## \$a 0877547637

040 Cataloging source -- (NR)*Indicators undefined.**Subfields used most often:***\$a** -- Original cataloging agency**\$c** -- Transcribing agency**\$d** -- Modifying agency (R)

Example: 040 ## \$a DLC
 \$c DLC
 \$d gwhs

100 Main entry -- Personal name -- (primary author)

(NR; there can be only one main entry)

Indicator 1: Type of personal name entry element

0 -- Forename

1 -- Surname (this is the most common form)

3 -- Family name

Indicator 2 undefined.

Indicator 2 became obsolete in 1990. Older records may display 0 or 1

*Subfields used most often:***\$a** -- Personal name**\$b** -- Numeration

- \$c** -- Titles and other words associated with a name (R)
- \$q** -- Fuller form of name
- \$d** -- Dates associated with a name (generally, year of birth)

Example: 100 1# \$a Gregory, Ruth W.
 \$q (Ruth Wilhelme),
 \$d 1910–

130 Main entry -- Uniform title -- (NR)

Indicator 1: Nonfiling characters

0-9 -- Number of nonfiling characters present (for initial articles, including spaces)

Indicator 2 undefined.

Indicator 2 became obsolete in 1990. (See 100 above.)

Subfields used most often:

- \$a** -- Uniform title
- \$p** -- Name of part/section of a work (R)
- \$l** -- Language of a work
- \$s** -- Version
- \$f** -- Date of a work

Example: 130 0# \$a Bible.
 \$p O.T.
 \$p Psalms.

240 Uniform title (NR)

Indicator 1: Uniform title printed or displayed

0 -- Not printed or displayed
 1 -- Printed or displayed (most common)

Indicator 2: Nonfiling characters

0-9 -- Number of nonfiling characters present (for initial articles, including spaces)

Subfields used most often:

- \$a** -- Uniform title
- \$l** -- Language of a work
- \$f** -- Date of a work

Example: 240 10 \$a Ile mystérieuse.
 \$l English.
 \$f 1978

245 Title Statement (NR)*Indicator 1:* Title added entry

(Should the title be indexed as a title added entry?)

0 -- No title added entry

(indicates a title main entry; i.e. no author is given)

1 -- Title added entry

(the proper indicator when an author given in 1XX; the most common situation)

Indicator 2: Nonfiling characters

0-9 -- Number of nonfiling characters present, including spaces; usually set at zero, except when the title begins with an article; e.g., for *The robe*, the second indicator would be set to 4. The letters *T*, *h*, *e*, and the space following them are then ignored in alphabetizing titles. The record will be automatically filed under "r" -- for *Robe*.

*Subfields used most often:***\$a** -- Title proper**\$h** -- Medium (often used for non-book media)**\$p** -- Name of part/section of a work (R)**\$b** -- Reminder of title (subtitles, etc.)**\$c** -- Remainder of title page transcription/Statement of responsibility

Example: 245 14 \$a The DNA story :
 \$b a documentary history of gene
 cloning /
 \$c James D. Watson, John Tooze.

246 Varying form of title (R)*Indicator 1:* Note/title added entry controller

1 -- Note, title added entry

3 -- No note, title added entry

Indicator 2: Type of title

-- No information provided

0 -- Portion of title

1 -- Parallel title

4 -- Cover title

8 -- Spine title

*Subfield used most often:***\$a** -- Title proper

Example: 246 3# \$a Four corners power review

250 Edition statement (NR)

Indicators undefined.

Subfield used most often:

\$a -- Edition statement

Example: 250 ## \$a 6th ed.

260 Publication, distribution, etc. (Imprint) (R)

Indicator 1: Sequence of publishing statements

-- No information provided

Indicator 2: Undefined

Subfields used most often:

\$a -- Place of publication, distribution, etc. (R)

\$b -- Name of publisher, distributor, etc. (R)

\$c -- Date of publication, distribution, etc. (R)

Example: 260 ## \$a New York :
 \$b Chelsea House,
 \$c 1986.

300 Physical description (R)

Indicators undefined.

Subfields used most often:

\$a -- Extent (number of pages) (R)

\$b -- Other physical details (usually illustration information)

\$c -- Dimensions (cm.) (R)

\$e -- Accompanying material (for example, "teacher's guide" or "manual")

Example: 300 ## \$a 139 p. :
 \$b ill. ;
 \$c 24 cm.

440 Series statement / Added entry--Title

This field was made obsolete in 2008 to simplify the series statement. See 490 and 830.

490 Series statement (No added entry is traced from field) (R)

Indicator 1: Specifies whether series is traced (whether an 8XX tag is also present)

0 -- Series not traced

1 -- Series traced (8XX is in record)

Indicator 2 undefined.

Subfield used most often:

\$a -- Series statement (R)

\$v -- Volume number (R)

Example: 490 1# \$a Colonial American craftsmen

500 General note (R)

Indicators undefined.

Subfield used most often:

\$a -- General note (Used when no specialized note field has been defined for the information. Examples: Notes regarding the index; the source of the title; variations in title; descriptions of the nature, form, or scope of the item.)

Example: 500 ## \$a Includes index.

504 Bibliography, etc. note (R)

Indicators undefined.

Subfield used most often:

\$a -- Bibliography, etc. note

Example: 504 ## \$a Includes bibliographical references.

505 Formatted contents note (R)

Indicator 1: Type of contents note

0 -- Complete contents

1 -- Incomplete contents (used with multivolume set when some volumes are not yet published)

2 -- Partial contents

Indicator 2: Level of content designation

-- Basic

Subfield used most often:

\$a -- Formatted contents note

Example: 505 0# \$a Pride and prejudice -- Emma
-- Northanger Abbey.

520 Summary, etc. note (R)

Indicator 1: Display constant controller

-- Summary

- 1 -- Review
- 2 -- Scope and content
- 3 -- Abstract

Indicator 2 undefined

Subfields used most often

- \$a** -- Summary, abstract, or annotation
- \$b** -- Expansion of summary note

Example: 520 ## \$a This basic guide to parliamentary procedure tells how to conduct and participate in a meeting properly.

600 Subject added entry -- Personal name (R)

Indicator 1: Type of personal name entry element

- 0 -- Forename
- 1 -- Surname (this is the most common form)
- 3 -- Family name

Indicator 2: Subject heading system/thesaurus (identifies the specific list or file which was used)

- 0 -- Library of Congress Subject Headings
- 1 -- LC subject headings for children's literature
- 2 -- Medical Subject Headings
- 3 -- National Agricultural Library subject authority file
- 4 -- Source not specified
- 5 -- Canadian Subject Headings
- 6 -- Répertoire de vedettes-matière
- 7 -- Source specified in subfield \$2

(Note regarding Sears subject headings: The MARC 21 format does not provide an assigned indicator for Sears subject headings. Therefore, an indicator of 7 is used, and the MARC defined code "sears" is placed in subfield \$2.)

Subfields used most often:

- \$a** -- Personal name (surname and forename)
- \$b** -- Numeration
- \$c** -- Titles and other words associated with a name (R)
- \$q** -- Fuller form of name
- \$d** -- Dates associated with a name (generally, year of birth)
- \$t** -- Title of a work
- \$v** -- Form subdivision (R)
- \$x** -- General subdivision (R)
- \$y** -- Chronological subdivision (R)
- \$z** -- Geographic subdivision (R)
- \$2** -- Source of heading or term (used with 2nd indicator of 7)

Example: 600 10 \$a Shakespeare, William,
 \$d 1564-1616
 \$x Comedies
 \$x Stage history.

Example: 600 10 \$a Shakespeare, William,
 \$d 1564-1616
 \$x Knowledge
 \$z Rome
 \$v Congresses.

Notice that subfields \$v, \$x, and \$z in the 600 field are repeatable. Subfields \$v, \$x, \$y, and \$z do not have to be in alphabetical order. They will be in the order prescribed by the instructions given by the subject heading system.

610 Subject added entry -- Corporate name (R)

Indicator 1: Type of corporate name entry element

0 -- Inverted name (not used with AACR2)

1 -- Jurisdiction name

2 -- Name in direct order

Indicator 2: Subject heading system/thesaurus.

See indicator 2 under 600

Subfields used most often:

\$a -- Corporate name or jurisdiction name as entry element

\$b -- Subordinate unit (R)

\$v -- Form subdivision (R)

\$x -- General subdivision (R)

\$y -- Chronological subdivision (R)

\$z -- Geographic subdivision (R)

\$2 -- Source of heading or term (used with 2nd indicator of 7)

Example: 610 10 \$a United States.
 \$b Army Air Forces
 \$v Biography.

650 Subject added entry -- Topical term (Most subject headings fit here.) (R)

Indicator 1: Level of subject

-- No information provided

Indicator 2: Subject heading system/thesaurus

(identifies the specific list or file which was used)

0 -- Library of Congress Subject Headings

1 -- LC subject headings for children's literature

- 2 -- Medical Subject Headings
- 3 -- National Agricultural Library subject authority file
- 4 -- Source not specified
- 5 -- Canadian Subject Headings
- 6 -- Répertoire de vedettes-matière
- 7 -- Source specified in subfield \$2

Note regarding Sears subject headings: The MARC 21 format does not provide an assigned indicator for Sears subject headings. Therefore, an indicator of 7 is used, and the MARC defined code "sears" is placed in subfield \$2.)

Subfields used most often:

- \$a -- Topical term
- \$v -- Form subdivision (R)
- \$x -- General subdivision (R)
- \$y -- Chronological subdivision (R)
- \$z -- Geographic subdivision (R)
- \$2 -- Source of heading or term used with 2nd indicator of 7)

Example: 650 #0 \$a Theater
 \$z United States
 \$v Biography
 \$v Dictionaries.

Notice that subfields \$v, \$x, and \$z in the 650 field are repeatable. Subfields \$v, \$x, \$y, and \$z do not have to be in alphabetical order. They will be in the order prescribed by the instructions given by the subject heading system.

651 Subject added entry -- Geographic name (R)

Indicator 1: undefined.

Indicator 2: Subject heading system/thesaurus.

See indicator 2 under 600

Subfields used most often:

- \$a -- Geographic name
- \$v -- Form subdivision (R)
- \$x -- General subdivision (R)
- \$y -- Chronological subdivision (R)
- \$z -- Geographic subdivision (R)
- \$2 -- Source of heading or term (used with 2nd indicator of 7)

Example: 651 #0 \$a United States
 \$x History
 \$v Chronology.

Notice that subfields \$v, \$x, and \$z in the 651 field are repeatable. Subfields \$v, \$x, \$y, and \$z do not have to be in alphabetical order. They will be in the order prescribed by the instructions given by the subject heading system.

700 Added entry -- Personal name (R)

Indicator 1: Type of personal name entry element

- 0 -- Forename
- 1 -- Surname (this is the most common form)
- 3 -- Family name

Indicator 2: Type of added entry

- # -- No information provided (most common; co-authors, editors, etc.)
- 2 -- Analytical entry (The values for Indicator 2 changed in 1994 with Format Integration, and older records may display additional values. An analytical entry involves an author/title of an item contained in a work.)

Subfields used most often:

- \$a** -- Personal name
- \$b** -- Numeration
- \$c** -- Titles and other words associated with a name (R)
- \$q** -- Fuller form of name
- \$d** -- Dates associated with a name (generally, year of birth)
- \$e** -- Relator term (such as ill.) (R)
- \$4** -- Relator code (R)

Example: 700 1# \$a Baldrige, Letitia.

710 Added entry -- Corporate name (R)

Indicator 1: Type of corporate name entry element

- 0 -- Inverted name (not used with AACR2)
- 1 -- Jurisdiction name
- 2 -- Name in direct order

Indicator 2: Type of added entry.

See Indicator 2 under 700

- # -- No information provided
- 2 -- Analytical entry

Subfields used most often:

- \$a** -- Corporate name or jurisdiction name as entry element
- \$b** -- Subordinate unit (R)

Example: 710 2# \$a Sunburst Communications (Firm)

740 Added entry -- Uncontrolled related/analytical title (R)

Indicator 1: Nonfiling characters

- 0-9 -- Number of nonfiling characters present (for initial articles, including

spaces)

Indicator 2: Type of added entry. See Indicator 2 under 700

-- No information provided

2 -- Analytical entry

(This field was redefined in 1994 with Format Integration. Prior to 1994, the field was also used for variant titles, such as a different wording on a spine title. In records created since Format Integration, those variant titles appear in a 246 field.)

Subfield used most often:

\$a -- Title

Example: 740 02 \$a Uncle Vanya.

800 Series added entry -- Personal name (R)

Indicator 1: Type of personal name entry element

0 -- Forename

1 -- Surname

3 -- Family name

Indicator 2 undefined.

Subfields used most often:

\$a -- Personal name

\$b -- Numeration

\$c -- Titles and other words associated with a name (R)

\$q -- Fuller form of name

\$d -- Dates associated with a name (generally, year of birth)

\$t -- Title of a work (the series)

\$v -- Volume number

Example: 800 1# \$a Fisher, Leonard Everett.
 \$t Colonial American craftsmen.

830 Series added entry -- Uniform title (R)

Indicator 1 undefined.

Indicator 2: Nonfiling characters

0-9 -- Number of nonfiling characters present (for initial articles, including spaces)

Subfield used most often:

\$a -- Uniform title

\$v -- Volume number

Example: 830 #0 \$a Railroads of America (Macmillan)

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Part VIII:

A List of Other Fields Often Seen in MARC Records

001	Control number
003	Control number identifier
005	Date and time of latest transaction
006	Fixed-length data elements -- additional material characteristics
007	Physical description fixed field
008	Fixed length data elements (See Part X)
022	International Standard Serial Number (ISSN)
037	Source of acquisition
041	Language code
043	Geographic area code
050	Library of Congress call number
060	National Library of Medicine call number
082	Dewey Decimal classification number (the one recommended by the Library of Congress; locally-assigned call numbers may appear elsewhere)
110	Main entry -- Corporate name (less frequent under AACR2 rules)
256	Computer file characteristics
263	Projected publication date (indicates a CIP -- Cataloging in Publication -- record)
306	Playing time
508	Creation/production credits note
510	Citation/references note (review sources)
511	Participant or performer note
521	Target audience note (first indicator: 0 = reading grade level, 1 = interest age level, 2 = interest grade level, 3 = special audience characteristics, 4 = motivation interest level)
530	Additional physical form available note
538	System details note
586	Awards note
656	Index term -- Occupation
730	Added entry -- Uniform title
852	Location
856	Electronic location and access
9XX	Reserved for local use. (They are used by vendors, systems, or individual libraries to exchange additional data)

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Part IX:

The Leader

There are 24 positions in the Leader, numbered from 00 to 23. For fuller explanation, see the *MARC 21 Format for Bibliographic Data*.

- 00-04 Record length (calculated by the computer for each record)
- 05 Record status
 - a = increase in encoding level
 - c = corrected or revised
 - d = deleted
 - n = new
 - p = increase in encoding from prepublication (previous CIP)
- 06 Type of record
 - a = language material
 - c = printed music
 - d = manuscript music
 - e = cartographic material
 - f = manuscript cartographic material
 - g = projected medium
 - i = nonmusical sound recording
 - j = musical sound recording
 - k = 2-dimensional nonprojectable graphic
 - m = computer file
 - o = kit
 - p = mixed materials
 - r = 3-dimensional artifact or naturally occurring object
 - t = manuscript language material
- 07 Bibliographic level
 - a = monographic component part
 - b = serial component part
 - c = collection
 - d = subunit
 - i = integrating resource
 - m = monograph/item
 - s = serial
- 08 Type of control
 - # = no specified type
 - a = archival
- 09 Character coding scheme
 - # = MARC-8
 - a = UCS/Unicode
- 10 Indicator count (always "2")
- 11 Subfield code count (always "2")
- 12-16 Base address of data (calculated by the computer for each record)
- 17 Encoding level
 - # = full level

- 1 = full level, material not examined
- 2 = less-than-full level, material not examined
- 3 = abbreviated level
- 4 = core level
- 5 = partial (preliminary) level
- 7 = minimal level
- 8 = prepublication level (CIP)
- u = unknown
- z = not applicable
- 18 **Descriptive cataloging form**
 - # = non-ISBD
 - a = AACR2
 - i = ISBD
 - u = unknown
- 19 **Multipart resource record level**
 - # = Not specified or not applicable
 - a = Set
 - b = Part with independent title
 - c = Part with dependent title
- 20 **Length of the length-of-field portion** (always "4")
- 21 **Length of the starting-character-position portion** (always "5")
- 22 **Length of the implementation-defined portion** (always "0")
- 23 **Undefined** (always "0")

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Part X:

Field 008 for Books

Field 008 is used for Fixed Length Data Elements ("Fixed Field Codes"). There are 40 character positions in field 008, numbered from 00-39. Undefined positions must contain either a blank (#) or a fill character (|). Positions 00-17 and 35-39 are defined the same way for all media.

The information shown here for positions 18-34 applies only to books. For explanation of all the positions below and for positions 18-34 for other media, see the *MARC 21 Format for Bibliographic Data*.

Note that field 008 has no indicators or subfield codes.

- 00-05 **Date entered on file (YYMMDD)**,
where Y=year, M=month, and D=day
- 06 **Type of date/publication status:**
 - b = no dates given; B.C. date involved
 - e = detailed date
 - s = single known date/probable date
 - m = multiple dates
 - r = reprint/reissue date (Date 1) and original date (Date 2)

- n = dates unknown
- q = questionable date
- t = publication date and copyright date
- | = no attempt to code

07-10 Date 1/beginning date of publication

11-14 Date 2/ending date of publication

Date fields contain the year(s) of publication. The type of date(s) in these elements are specified in fixed field element 06: Type of date/publication status. (For further details, see the field 008 description in the *MARC 21 Format for Bibliographic Data*.)

15-17 Place of publication, production, or execution

For example:

pk# = Pakistan

cau = California (US)

(For a full list of codes used in these positions, see the *MARC Code List for Countries*.)

18-21 Illustrations (up to 4 codes):

- # = no illustrations
- a = illustrations
- b = maps
- c = portraits
- d = charts
- e = plans
- f = plates
- g = music
- h = facsimiles
- i = coats of arms
- j = genealogical tables
- k = forms
- l = samples
- m = phonodisc, phonowire, etc.
- o = photographs
- p = illuminations
- | = no attempt to code

22 Target audience:

- # = unknown or not specified
- a = preschool
- b = primary
- c = pre-adolescent
- d = adolescent
- e = adult
- f = specialized
- g = general
- j = juvenile
- | = no attempt to code

23 Form of item:

- # = none of the following
- a = microfilm

b = microfiche
 c = microopaque
 d = large print
 f = braille
 r = regular print reproduction
 s = electronic
 | = no attempt to code

24-27 Nature of contents (up to 4):

= no specified nature of contents
 a = abstracts/summaries
 b = bibliographies (is one or contains one)
 c = catalogs
 d = dictionaries
 e = encyclopedias
 f = handbooks
 g = legal articles
 i = indexes
 j = patent document
 k = discographies
 l = legislation
 m = theses
 n = surveys of literature
 o = reviews
 p = programmed texts
 q = filmographies
 r = directories
 s = statistics
 t = technical reports
 u = standards/specifications
 v = legal cases and notes
 w = law reports and digests
 z = treaties
 | = no attempt to code

28 Government publication:

= not a government publication
 i = international intergovernmental
 f = federal/national
 a = autonomous or semi-autonomous component
 s = state, provincial, territorial, dependent, etc.
 m = multistate
 c = multilocal
 l = local
 z = other type of government publication
 o = government publication -- level undetermined
 u = unknown if item is government publication
 | = no attempt to code

29 Conference publication:

0 = not a conference publication
 1 = conference publication

- | = no attempt to code
- 30 **Festschrift:**
 - 0 = not a festschrift
 - 1 = festschrift
 - | = no attempt to code
- 31 **Index:**
 - 0 = no index
 - 1 = index present
 - | = no attempt to code
- 32 **Undefined (since 1990)** (Earlier records may contain the values 0 or 1)
 - # = Undefined
 - | = no attempt to code
- 33 **Literary form:**
 - 0 = not fiction (not further specified)
 - 1 = fiction (not further specified)
 - c = comic strips
 - d = dramas
 - e = essays
 - f = novels
 - h = humor, satires, etc.
 - i = letters
 - j = short stories
 - m = mixed forms
 - p = poetry
 - s = speeches
 - u = unknown
 - | = no attempt to code
- 34 **Biography:**
 - # = no biographical material
 - a = autobiography
 - b = individual biography
 - c = collective biography
 - d = contains biographical information
 - | = no attempt to code
- 35-37 **Language:**

A three-letter code. For example: eng fre ger spa rus ita

(For a full list of codes used in these positions, see the [MARC Code List for Languages](#).)

- 38 **Modified record:**
 - # = not modified
 - x = missing characters (because of characters unavailable in MARC character set)
 - s = shortened
 - d = "dashed-on" information omitted
 - r = completely romanized/printed cards in script
 - o = completely romanized/printed cards romanized
 - | = no attempt to code
- 39 **Cataloging source:**

= national bibliographic agency
c = cooperative cataloging program
d = other sources
u = unknown
| = no attempt to code

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[Library of Congress Help Desk](#) (10/27/2009)

APPENDIX C

Appendix C. Materials Considered

1006	Kanbara, M., Okuma, T., Takemura, H., & Yokoya, N. (2000, March). A stereoscopic video see-through augmented reality system based on real-time vision-based registration. In <i>Proceedings IEEE Virtual Reality 2000</i> , pp. 255-262 (“ <i>Kanbara</i> ”)
1006A	Copy of <i>Kanbara</i> , obtained from IEEE.
1006B	Bibliographic and MARC records for <i>Proceedings IEEE Virtual Reality 2000</i> that contains <i>Kanbara</i> , available at https://catalog.lindahall.org/permalink/01LINDAHALL_INST/19lda7s/alma993342023405961 from the online catalog of the Linda Hall Library.
1006C	Profile of the Linda Hall Library, available at http://librarytechnology.org/library/2294 .
1006D	Copyright registration record for <i>Proceedings IEEE Virtual Reality 2000</i> that contains <i>Kanbara</i> , available at https://cocatalog.loc.gov/cgi-bin/Pwebrecon.cgi?Search_Arg=IEEE+Virtual+Reality+2000&Search_Code=TALL&PID=MglrciZ6zXgZrTlptx1wITfSwzkh&SEQ=20250322233708&CNT=25&HIST=1 from the US Copyright Office.
1006E	IEEE Metadata record for <i>Kanbara</i> , available at https://ieeexplore.ieee.org/abstract/document/840506 from IEEE Xplore
1006F	Website of IEEE Xplore archived by Internet Archive on February 7, 2001, available at https://web.archive.org/web/20010207003457/http://ieeexplore.ieee.org/lpdocs/epic03/
1006G	Citations to <i>Kanbara</i> , obtained from Google Scholar.
App A	Hsieh-Yee CV
App B	Parts VII to X of Understanding MARC Bibliographic, available at https://www.loc.gov/marc/umb/um07to10.html

EXHIBIT 1006A

A Stereoscopic Video See-through Augmented Reality System Based on Real-time Vision-based Registration

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Abstract

In an augmented reality system, it is required to obtain the position and orientation of the user's viewpoint to display the composed image maintaining correct registration of real and virtual worlds. All the procedures must be done in real-time. This paper proposes a method for augmented reality with a stereo vision sensor and video see-through head mounted display. It can synchronize the display-timing between the virtual and real worlds, so that an alignment error is reduced. The method calculates camera parameters from three markers in image sequences captured by a pair of stereo cameras mounted on a HMD. In addition, it estimates depth of real world from a pair of stereo images to generate a composed image maintaining consistent occlusions between real and virtual objects. A region of depth estimation is efficiently limited by calculating a position of virtual object using camera parameters. Finally, we have developed a video see-through augmented reality system which mainly consists of a pair of stereo cameras mounted on the HMD and a standard graphics workstation. The feasibility of the system has been successfully demonstrated with experiments.

1. Introduction

This paper describes a method of merging real and virtual worlds for a video see-through augmented reality system. Augmented reality produces an environment in which virtual objects are superimposed on a user's view of the real environment. Augmented reality has received a great deal of attention as a new method for displaying information or increasing the reality of virtual environments. A number of applications have already been proposed and demonstrated [1]. For example, Feiner et al. proposed an augmented re-

ality system that explains to an end-user how to maintain a printer using see-through HMD[2]. State et al. presented an augmented reality system applied to a medical procedure known as the ultrasound-guided needle biopsy of a breast[3].

To implement an augmented reality system, we must resolve some problems. A geometric registration is especially the most important problem because the problem is a principal factor which provides a user with a sense of incongruity. The registration includes a problem of geometric alignment of the real and virtual coordinates and a problem of resolving occlusion between real and virtual objects. The former problem is considered as one of acquiring the position and orientation of the user's viewpoint in terms of registering the real and virtual worlds geometrically[4]. The latter problem can be resolved by measuring the real world in advance when the real world is static. However, since the real world is usually dynamic, we must estimate a depth of the real scene in real-time.

In addition to the problems above, we need to discuss how to combine a method of visually merging the real and virtual worlds and a method of resolving geometric registration because there are some methods of composition that cannot present correct occlusion. The following briefly reviews the respective methods.

In general, the following two major methods are known for acquiring the user's viewpoint in geometric registration.

- A method that uses a 3-D tracker, such as electromagnetic, ultrasonic or mechanical trackers; for example, see [2, 3].
- A method that estimates the user's viewpoint by using camera images captured at the user's viewpoint; for example, see [5, 6, 7]. This is sometimes referred to as

a vision sensor.

The 3-D trackers used in the former method can directly acquire 3-D position and orientation of receivers. However, the drawbacks of the method are that the system requires a special equipment and its measurement range is limited to a relatively narrow area. On the other hand, the latter can estimate the position and orientation of the user's viewpoint from an acquired image and there is potentially no limitation in measurement range. When the relationship between a camera position and the user's viewpoint is known, the user's viewpoint can be obtained by calculating the camera parameters from captured images. This means that the traditional techniques studied in the field of computer vision can be used to measure the viewpoint [8].

There exist two methods of showing a user images in which the real and virtual environments are merged.

- An optical see-through shows a user the real environment through a half-transparent mirror and the virtual environment reflected on the half-transparent mirror.
- A video see-through shows a user image sequences of the real environment captured by a camera and the virtual environment overlaid upon the image sequences.

The optical see-through system can show a user the real environment without delay. However, virtual objects are not synchronized with the real world imagery. This may cause the displacement between real and virtual objects. This type of system has another drawback that the amount of light from the real environment is reduced, because it uses a half-transparent mirror. In contrast, the video see-through system makes the display-timing of the real environment and that of the virtual environment synchronous. Therefore, it reduces the alignment error. However, the augmented real environment is shown to the user with delay [9].

We focus on an augmented reality system that adopts the combination of vision sensor and video see-through system. Since the image captured by a camera is used both to estimate camera parameters and to show the user the real environment, the combination is able to synchronize the real and virtual environments and reduce alignment error between them. For implementation of an augmented reality system with highly realistic sensations, all the processes from acquisition of the user's viewpoint to displaying the composed image by using obtained viewpoint must be done in real-time.

This paper is structured as follows. Section 2 briefly reviews related work. Section 3 describes the algorithms to calculate camera parameters and to estimate the depth of real world as well as stereo image composition with examples. In Section 4, the experimental results with the proposed methods and the discussion about the prototype system are described. Finally, Section 5 summarizes the present work.

2. Related Work

The registration problem is considered as a problem of acquiring the position and orientation of the user's viewpoint. Using a vision sensor, if we assume that the optical axes of the cameras are set to be parallel to viewer's gaze direction, the acquisition of position and orientation of the user's viewpoint is equal to the estimation of external camera parameters. A number of methods of estimating camera parameters from tracked feature points in the image sequence have been proposed by several research groups [6, 10, 11, 12]. The authors have already built a prototype of a vision-based video see-through augmented reality system with a single camera that uses four colored markers as feature points [5]. In this system, the position and orientation of the user's viewpoint are calculated from the positions of the feature points in the captured image. However, the monocular vision system does not show the user the stereoscopic view. Moreover, virtual objects that should be behind the real objects occlude the real objects, so that the occlusion conflict occurs. State, et al. [13] proposed a video see-through augmented reality system that provides the user with the stereoscopic view using a pair of stereo cameras, but the system could not show the user the images of virtual objects with a dynamic real world.

This paper describes algorithms to realize a stereo-vision based augmented reality. The camera parameters can be estimated from captured stereo images containing three features in the scene. In addition, a depth of the real world can be estimated by a stereo vision technique. Static real objects can be properly treated by the state of the art of stereo vision techniques in video see-through augmented reality applications using standard workstations[14, 15]. However, dynamically moving arbitrary objects are still difficult to be mixed with CG objects in real-time without special hardwares [7, 16, 17], maintaining correct occlusions among them. The method proposed in the paper overcomes this problem by estimating depth only for regions where virtual objects are composed; that is, it is an augmented reality-oriented approach to stereo vision.

3. Algorithms for Stereoscopic Video See-through Augmented Reality

In order to evaluate the feasibility of the augmented reality environment that uses a pair of stereo cameras, the prototype system of augmented reality was implemented. The system estimates camera parameters using a pair of stereo images. The system also realizes the occlusion of virtual objects by real objects.

Figure 1 shows the flowchart of the prototype system. A pair of stereo image sequences captured by stereo cameras

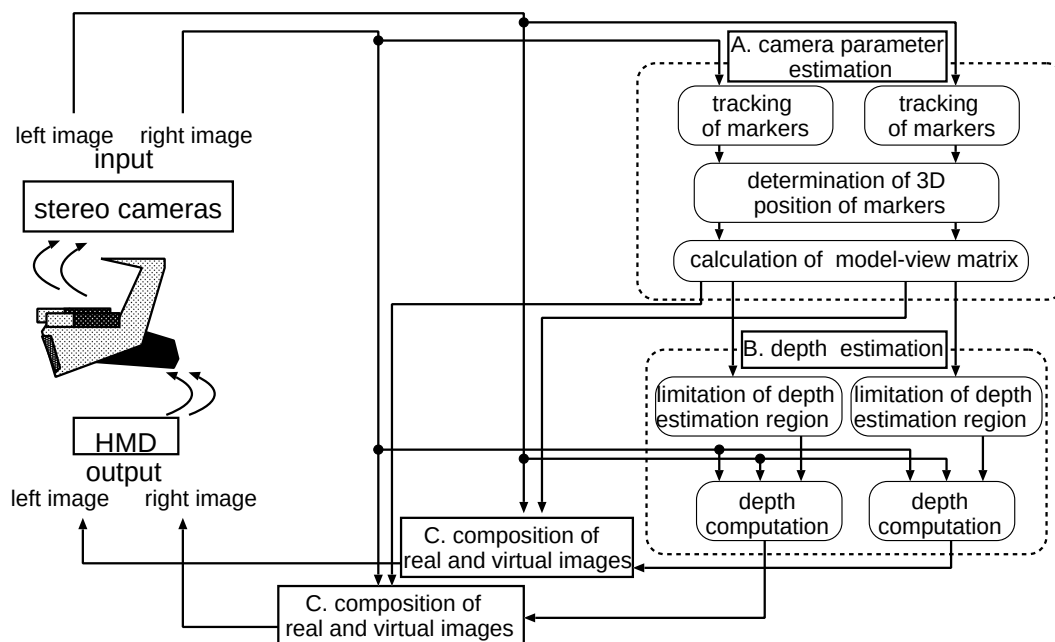


Figure 1. Flow diagram of stereoscopic video see-through augmented reality system.

are fed into a standard workstation. First, in order to capture the sight of user's viewing direction, the stereo cameras are mounted on a HMD. The camera parameter is estimated using these image sequences of the real world containing markers. Next, depth of real world is estimated using both these image sequences and the camera parameter. Finally, the stereo images are composed with the computer graphics (CG) images (images of virtual objects) and are outputted to the HMD that is worn by the user.

In the following sections, the details of the camera parameter estimation, depth estimation of the real world and the image composition are described.

3.1. Camera parameter estimation

In our prototype system, blue markers are used as feature points in a real environment. It should be noted that a pair of stereo cameras are calibrated in advance by using a standard technique[18]. The following three steps are executed to estimate camera parameters.

1. From the input images, blue regions are extracted and the positions of markers in the images are obtained.
2. The markers' 3-D positions in the camera coordinate system are estimated by using a stereo matching algorithm.
3. A projection matrix (model-view matrix) that represents the relationship between the real and virtual en-

vironments is calculated using 3-D coordinates of extracted markers.

Let us describe these steps in more detail in the following.

3.1.1. Extraction of markers. The extraction of blue marker regions from the entire image needs considerable amount of computation. Therefore, only in the first frame of the image sequence, the blue region extraction is performed over the entire image. In the subsequent frames, extracted regions are tracked by using the results obtained in the previous frame. The extracted and tracked regions are used to calculate the screen coordinate of each marker.

In the first frame of the image sequence, the following steps are used to extract blue marker regions.

1. The entire images in the first stereo pair are scanned to extract blue regions.
2. The center of gravity of each blue region is treated as the screen coordinate of the marker.
3. When three markers are found in both left and right images, stereo matching is performed based on the epipolar constraint. All markers are then labeled (Labels: 1,2,3).

When the processing speed is fast enough, the markers' positions in adjacent frames can be assumed to be close to each other. Thus the following steps are used in the subsequent frames in the image sequence.

1. A search area for each marker is determined in the current frame based on the position of the marker in the previous frame.
2. The center of gravity for all blue pixels in the search area is calculated and is treated as the screen coordinate of the marker. The matching between left and right images in the first frame is used to determine the stereo pair of markers between the current left and right images.

When the stereo matching of markers or tracking of markers fails, the system starts over the procedure for the first frame described above.

3.1.2. Determination of 3-D position of markers. In this phase of the process, the system determines the 3-D position of each marker. The relationship between two cameras and a marker is illustrated in Figure 2. The origin of the camera coordinate system is placed at the middle between the centers of projection of two cameras. The X -axis is set along the baseline of the cameras. The Z -axis is set to the direction parallel to the optical axes of the cameras. A marker at $P(X, Y, Z)$ in 3-D space is projected onto the left and right images at $P_l(x_l, y_l)$ and $P_r(x_r, y_r)$ in the screen coordinates, respectively. Then following equations stand:

$$\begin{aligned} X &= \frac{B(x_l + x_r)}{2(x_l - x_r)}, \\ Y &= \frac{B(y_l + y_r)}{2(x_l - x_r)}, \\ Z &= \frac{fB}{x_l - x_r}, \end{aligned}$$

where f is the focal length and B is the baseline length. Thus when f and B are known, $P(X, Y, Z)$ is calculated from the coordinates $P_l(x_l, y_l)$ and $P_r(x_r, y_r)$.

3.1.3. Calculation of model-view matrix. In order to compose the image of a real environment and CG objects, A model-view matrix that represents the transformation from the world coordinate, in which the shape of CG objects is defined, to the camera coordinate is required. Figure 3 illustrates the relationship between the world and camera coordinates as well as markers. Among a model-view matrix - $\mathbf{M}$, a position of a point in the world coordinate system - $\mathbf{w}$, and its position in the camera coordinate system - $\mathbf{c}$, the following equation stands.

$$\mathbf{c} = \mathbf{M}\mathbf{w}.$$

The matrix $\mathbf{M}$ is a rigid transformation in homogenous coordinates consisting of a rotation $\mathbf{R}$ and a translation $\mathbf{T}$ as follows.

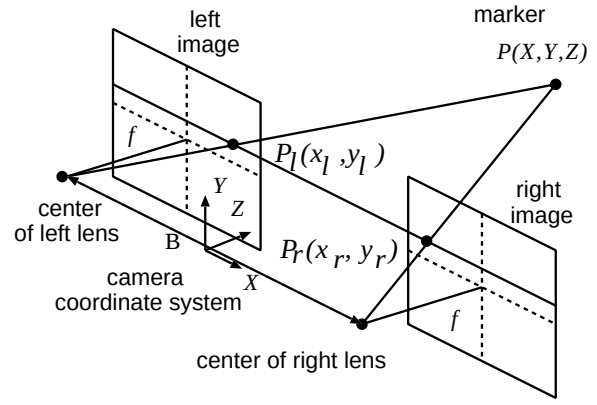


Figure 2. Geometry of stereoscopic projection of a marker.

$$\mathbf{M} = \left[\begin{array}{ccc|c} & \mathbf{R} & & \mathbf{T} \\ \hline 0 & 0 & 0 & 1 \end{array} \right].$$

In the prototype system, the world coordinate system is simply defined as follows:

- The origin is set at the marker labeled as No. 1 (M1 in Figure 3).
- The x -axis is set on the line that connects the markers labeled as No. 1 and No. 2 (M2 in Figure 3).
- The $x - y$ plane is set on the plane on which three markers reside.

According to the definition above, the translation component $\mathbf{T}$ can be given by the camera coordinate position of the marker No. 1. The rotation component $\mathbf{R}$ can be calculated with the following steps.

1. When the positions of the markers Nos. 1, 2, and 3 are given as $\mathbf{V}_1$, $\mathbf{V}_2$, and $\mathbf{V}_3$, respectively, the direction of the vector of each axis of the world coordinate ($\mathbf{x}_n$, $\mathbf{y}_n$, $\mathbf{z}_n$) can be defined as follows.

$$\begin{aligned} \mathbf{x}_n &= \mathbf{V}_2 - \mathbf{V}_1, \\ \mathbf{y}_n &= (\mathbf{V}_3 - \mathbf{V}_1) - \frac{\mathbf{x}_n \cdot (\mathbf{V}_3 - \mathbf{V}_1)}{\mathbf{x}_n \cdot \mathbf{x}_n} \mathbf{x}_n, \\ \mathbf{z}_n &= \mathbf{x}_n \times \mathbf{y}_n. \end{aligned}$$

2. Normalize $\mathbf{x}_n$, $\mathbf{y}_n$, and $\mathbf{z}_n$ into $\mathbf{x}'_n$, $\mathbf{y}'_n$, and $\mathbf{z}'_n$, respectively.

$$\mathbf{x}'_n = \frac{\mathbf{x}_n}{\|\mathbf{x}_n\|}, \quad \mathbf{y}'_n = \frac{\mathbf{y}_n}{\|\mathbf{y}_n\|}, \quad \mathbf{z}'_n = \frac{\mathbf{z}_n}{\|\mathbf{z}_n\|}.$$

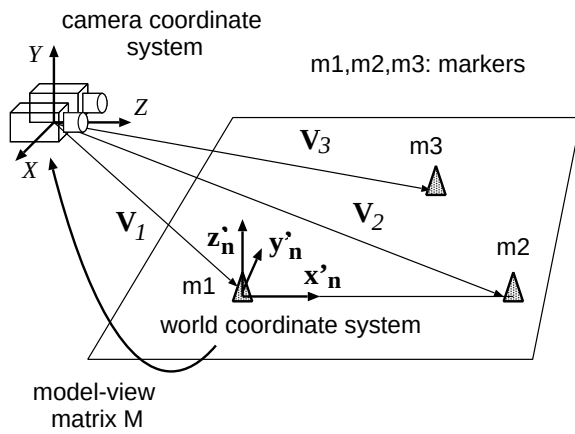


Figure 3. Relationship between the world and camera coordinates.

3. $\mathbf{R}$ can be determined by using $x'_n, y'_n,$ and z'_n as follows.

$$\mathbf{R} = [x'_n \ y'_n \ z'_n].$$

By using $\mathbf{T}$ and $\mathbf{R}$, the model-view matrix $\mathbf{M}$ can be uniquely determined. Now it should be noted that the geometric alignment of the real and virtual world coordinates is achieved by the model-view matrix.

3.2. Depth estimation of real world

In this section, the depth estimation of real world is described. The depth estimation is used to compose the image of the virtual objects and the image of the real world without occlusion conflicts. In order to avoid occlusion conflicts, we need the depth information of only the region onto which virtual objects are projected. When the positions of virtual objects are known, the region for depth estimation can be limited as shown in Figure 4. Therefore, the depth estimation region of real world can be determined by projecting a CG object's bounding box using the model-view matrix estimated in Section 3.1. The following steps describe a method of depth estimation of real world.

1. A position of the CG object in the world coordinate system is transformed into its position in the camera coordinate system using the estimated model-view matrix $\mathbf{M}$.
2. A bounding box of the virtual object is projected onto the left image as shown in Figure 4. A depth estimation region is obtained as a bounding rectangle of the projected box. The same process is done for the right image as well.
3. By adopting the Sobel filter, edges are detected in the region of depth estimation on the left and right images.

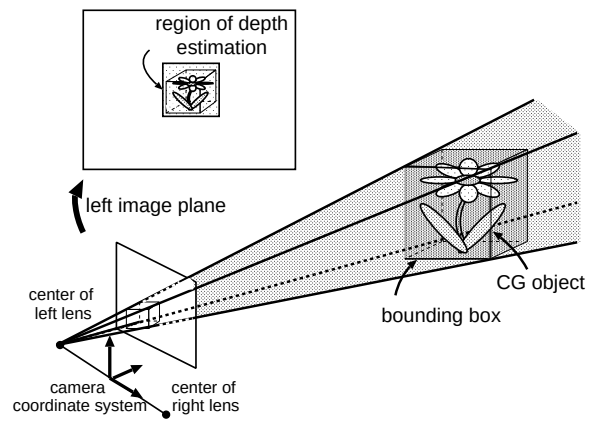


Figure 4. Determination of depth estimation region.

4. Stereo matching is performed and the depth value is computed. Note that only pixels on detected edges in the left image are matched to those in the right image, matching window size is 5×5 pixels, and similarity measure is the sum of absolute differences (SAD). In the same way, the right image as a reference image is matched to the left image.
5. Matching errors are excluded by considering the consistency between left-to-right and right-to-left matchings. The depth values at the pixels between the edges are interpolated.

3.3. Composition of real and CG images

By using the estimated model-view matrix and the depth map of the real world, CG images of virtual objects are mixed into the image of real world. At this stage, the depth of real world and each virtual object are compared. When the real objects are closer to the user's viewpoint, a transparent virtual object is drawn at the 3-D position where the real objects exist. By using a hardware z buffering algorithm, the virtual objects that are farther than the transparent objects are not actually drawn on the frame buffer. Therefore the composed image is looked as if the real objects are occluding the virtual objects. These rendering steps are illustrated with examples in Figure 5.

First, only the background image of a real scene is rendered on the frame buffer as in Figure 5 (a). Z-buffer value is also set to the farthest value through out the screen. Then, Z-buffer of the real objects are set to the depth of the real objects in Figure 5 (c). The regions of real objects are illustrated with gray levels of depth in Figure 5 (b). Finally, the virtual objects are rendered by using the model-view matrix in Figure 5 (d),(e). These steps are applied to both left

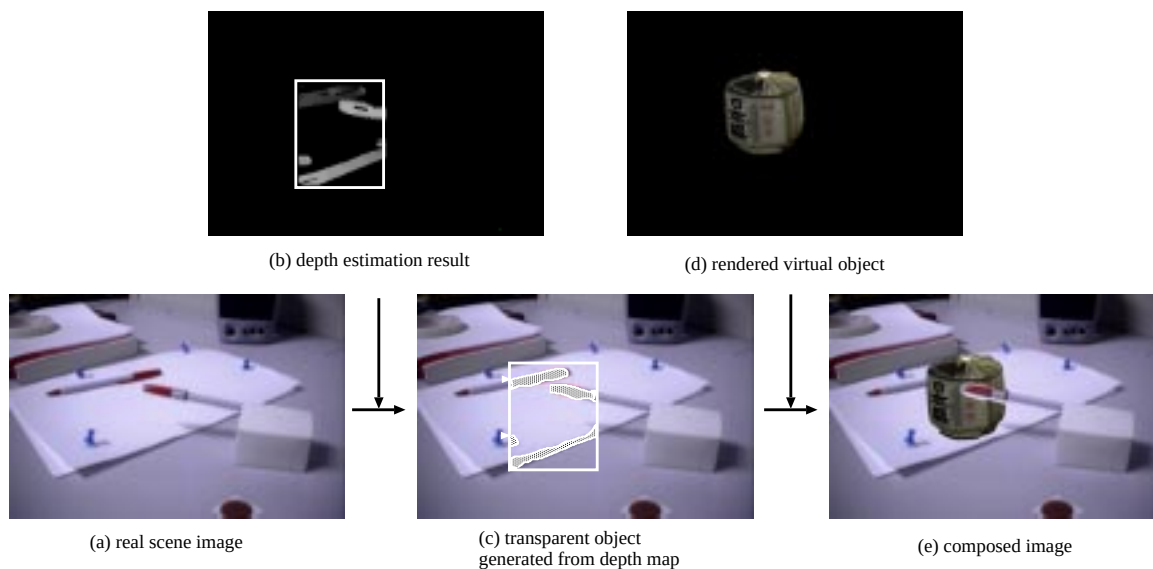


Figure 5. Process of image composition.



Figure 6. Appearance of stereoscopic video see-through HMD.

and right images for obtaining a stereo pair of composite images.

4. Experiments

4.1. Prototype system and results

In the present system, two small identical CCD cameras (Toshiba IK-UM42) are mounted on a HMD (Olympus Media Mask) as shown in Figure 6. An optical see-through function of the HMD is not used; that is, it works in closed-view mode. The baseline length between two cameras is set to 6.5 cm. The optical axes of the cameras are set to be parallel to the viewer's gaze direction (actually the head direction). The images captured by the cameras are fed into a graphics workstation (SGI Onyx2 IR: 16CPU

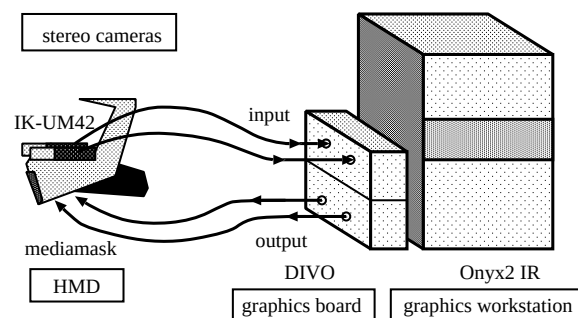


Figure 7. Hardware configuration of prototype system.

MIPS R10000 195MHz) through the digital video interface (DIVO). The input real world images are merged with virtual objects and outputted from the DIVO interface to the HMD. The hardware configuration of the whole system is illustrated in Figure 7.

Figure 8 shows the result of the stereoscopic image composition. The images on the first and second rows (Figure 8(a),(b)) show the composition of a virtual sake cask into a real desktop scene by using three markers placed on the desktop. As is observed from the Figure 8, the stereoscopic composition of the virtual sake cask and the real environment are realized. In the third and fourth rows (Figure 8(c),(d)), real objects are placed in front of or back of the virtual sake cask. As we can see from these examples, the occlusion between the virtual and real objects are correctly established. Moreover, the stereoscopic video see-through HMD gives a good depth sensation to users and has improved the quality of augmented reality.

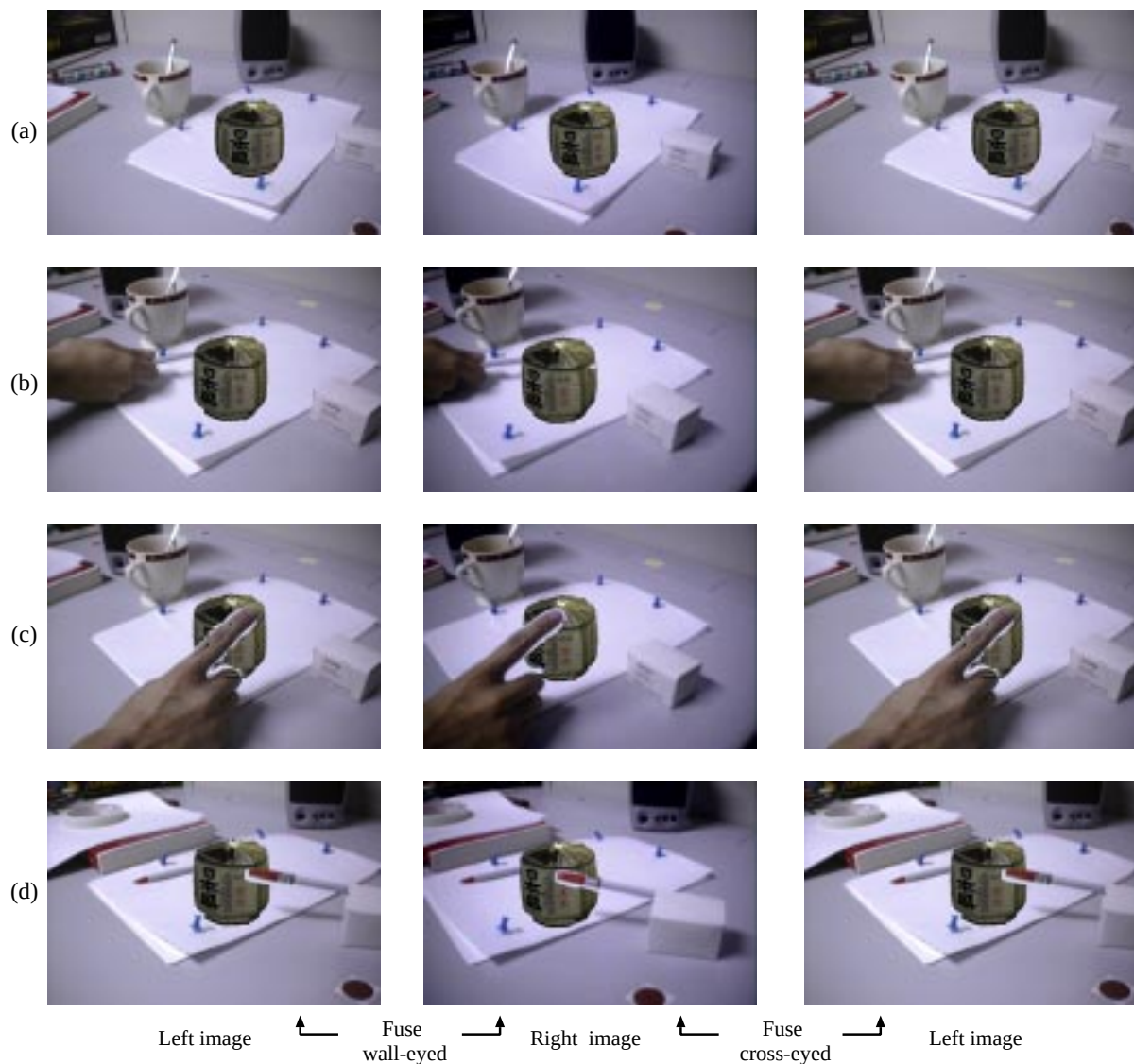


Figure 8. Composed stereo images.

4.2. Discussion

The average frame rate of the system is 10 frames per second, when the virtual object shown in Figure 8 (about 3700 polygons with a texture) is synthesized. This means that 100 ms are allocated for each frame. The approximate processing time at each stage is as follows: 20 ms for camera parameter estimation, 40 ms for depth estimation of real world, 30 ms for image composition with CG. Due to the nature of video see-through augmented reality, there is no synchronization error between the real scene and virtual objects. On the other hand, an entire scene has a time latency of 133 ms.

If the system cannot locate at least three markers in the real environment, it cannot estimate the model-view matrix.

To overcome this problem, we should set more markers in the real environment, so that the system could stably estimate the model-view matrix.

The vision sensor essentially has no limitations in measurement range. However, the present prototype system actually has a limitation in measurement range because the system uses a limited number of predefined markers. If we could automatically detect and track feature points other than markers in a real scene to calculate the model-view matrix, a measurement range of the system would be extended.

5. Conclusion

In this paper, we have proposed a method of composing virtual (CG) objects with real world images in real-time

for video see-through augmented reality applications. As a pilot study, we also have developed a prototype of stereoscopic video see-through augmented reality system, which is implemented by using existing computer vision techniques on a graphics workstation and a HMD with a pair of CCD cameras. The prototype system can produce composite images of real and virtual objects nearly at video-rate, maintaining correct occlusions between CG objects and real objects. It should be noted that the system can provide a user with excellent 3-D depth sensation of augmented environments. We have proven that the stereo-vision based video see-through augmented reality system is feasible and has the possibility of building up actual applications.

In the future work, we will concentrate our attention on robust estimation of the model-view matrix in some ways; for example, (1) using more than three markers, (2) automatic detection and tracking of natural feature points in a real scene without predefined markers.

Acknowledgments

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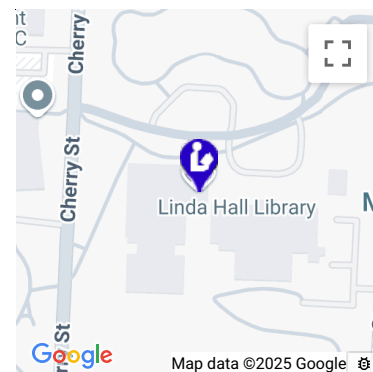
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In an augmented reality system, it is required to obtain the position and orientation of the user's viewpoint in order to display the composed image while maintaining a correct registration between the real and virtual worlds. All the procedures must be done in real time. This paper proposes a method for augmented reality with a stereo vision sensor and a video see-through head-mounted display (HMD). It can synchronize the display timing between the virtual and real worlds so that the alignment error is reduced. The method calculates camera parameters from three markers in image sequences captured by a pair of stereo cameras mounted on the HMD. In addition, it estimates the real-world depth from a pair of stereo images in order to generate a composed image maintaining consistent occlusions between real and virtual objects. The depth estimation region is efficiently limited by calculating the position of the virtual object by using the camera parameters. Finally, we have developed a video see-through augmented reality system which mainly consists of a pair of stereo cameras mounted on the HMD and a standard graphics workstation. The feasibility of the system has been successfully demonstrated with experiments.

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