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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	067055-002099
	Application Number	
Title of Invention	VIRTUAL MIRROR	

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Title of Invention	VIRTUAL MIRROR	

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Application Information:

Title of the Invention	VIRTUAL MIRROR		
Attorney Docket Number	067055-002099	**Small Entity Status Claimed**	☒
Application Type	Provisional		
Subject Matter	Utility		
Suggested Class (if any)		**Sub Class (if any)**	
Suggested Technology Center (if any)			
Total Number of Drawing Sheets (if any)		**Suggested Figure for Publication (if any)**	

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)
☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

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Prior Application Status		Remove

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	067055-002099
	Application Number	
Title of Invention	VIRTUAL MIRROR	

Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)

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Application Number	Country i	Filing Date (YYYY-MM-DD)	Priority Claimed
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	067055-002099
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	067055-002099
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Title of Invention	VIRTUAL MIRROR	

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First Name	Joseph	Last Name	Bach	Registration Number	37771

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Nov 2012

Provisional of Virtual Mirror Technology - EyesMatch / Body match Computerized Method.

Background of Invention:

The conventional mirror is the common and most reliable tool for an individual to explore its actual appearance, in real time.

A few alternatives have been proposed by prior art around the combination of a camera and a screen to replace the conventional mirror, though these techniques are not convincing and are not yet accepted as a reliable image of the individual as if he was looking at himself at a conventional mirror.

In this invention we are proposing a novel technology (computerized method) to address the challenges of converting a still image or 2D/3D video created by one or more cameras with/without other sensors, into a mirror experience.

Problem to Solve:

What happens when we look at a conventional or passive mirror?

When a user looks at himself in the mirror, what he actually sees is the reflection of himself as if he was standing at a distance that is double the distance from him to the mirror.

In figure 1 the user standing at distance D1 will see himself at a distance equal to 2xD1. A user standing at distance D2 will see himself at a distance 2xD2. In addition, the angle of the user's Field of View (FOV) changes when the user gets closer to the mirror. FOV is the specular reflecting angle (β) from the mirror to the user's eye and to the user's shoes. When the user approaches the mirror, the FOV angle increases which is why he continues to see the same size reflection (FOV1 < FOV2) so the user actually sees himself roughly at the same size, but closer.

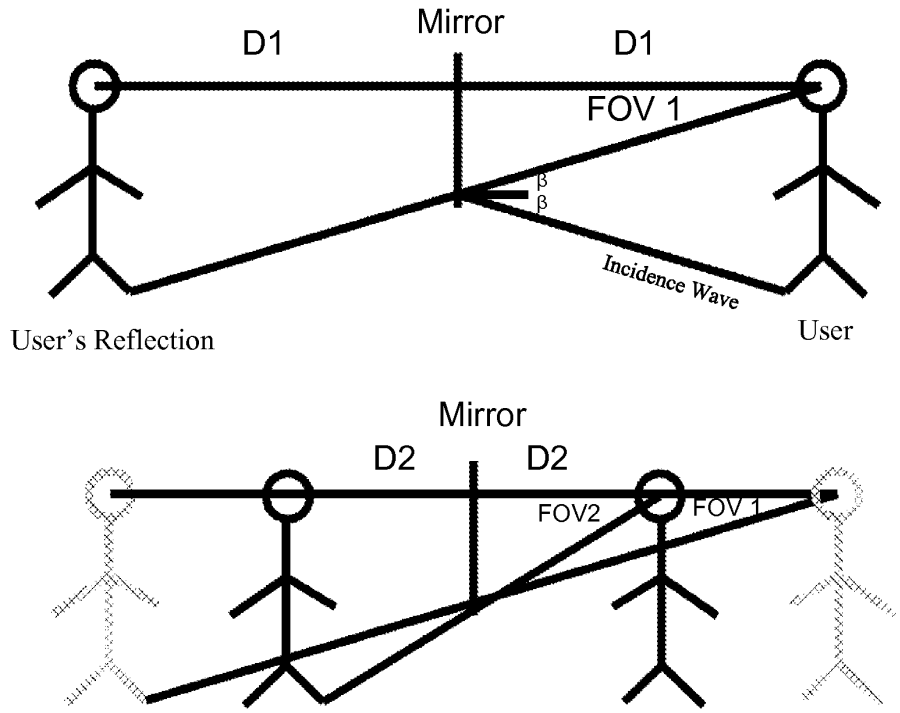


Figure 1 Conventional Passive Mirror

Additional notes to mention:

1. When the user approaches the mirror the reflection of his eyes will always stay on the same virtual line into the mirror.

2. If one looks in a mirror, one's image reverses (e.g., if one raises one's right hand, his left hand will appear to go up in the mirror). However, a mirror does not "swap" left and right, any more than it swaps top and bottom. A mirror reverses the forward/backward axis, and we define left and right relative to front and back.

3. Because the image in the mirror is virtual (as shown in figure 1), the mirror can be smaller than the full body and the user still see the reflection of his full body. The reason for that is the specular reflection (in figure 1 – the angle of incidence β equals to the reflection angle β) can increase the effective field of view while user approaches the mirror.

4. Users with two eyes can see themselves in 3D.

Imitating the mirror's unique characteristics with a screen and camera, requires a sophisticated computerized method.

The ideal solution:

In an ideal setup (as depicted in Figure 2 below) a screen + camera + computerized method setup, could create a convincing mirror experience. The ideal setup would probably include the following elements:

1. The camera would be able to **move on a parallel plate** behind the screen, in correspondence with the user's eye location to create a convincing eye-to-eye look experience.

   Problem: It is not practical to locate a camera behind a regular screen simply because it will block the camera's view. In theory it is possible to overcome this problem by using a semitransparent screen or multiple pinholes with multiple cameras, though it may be too expensive and complex.

2. **An Adaptive FOV** is required to compensate for the changes between the distances between the user to the screen, so the user will see his image at the same size. This can be solved for using the camera's zoom (digital/mechanical).

   Traditional camera has fixed FOV (with digital zoom capability) or mechanical tunable FOV. In order to create an adaptive FOV the system needs to manipulate the resolution, or to control the camera zoom and focus real-time based on user tracking – an adaptive system.

3. The image needs to be **flipped vertically** to support the right-to-left behavior of the mirror.

   Relatively easy image transformation

4. Full or nearly **full body size screen**.

   As we saw in Figure 1 the mirror can be smaller than the user and still show a full body reflection, though the screen needs to be large enough to support a full body image.

5. In addition, in order to support 3D system the setup will require **two cameras at a distance corresponding to the distance between the user's eyes**, or one camera with two effective virtual points of view.

   A convincing 3D experience will also require the implementation of an adaptive closed-loop method that can change the creation of a 3D image as a function of the distance. When the user looks at his reflection in the mirror he sees himself in 3D, though when he approaches the mirror or walks away, the angle from his eyes to his reflection changes, which also changes the depth of the 3D image. (Note - 3D is important road map though probably will not be necessary to create a convincing mirror experience for phase 1).

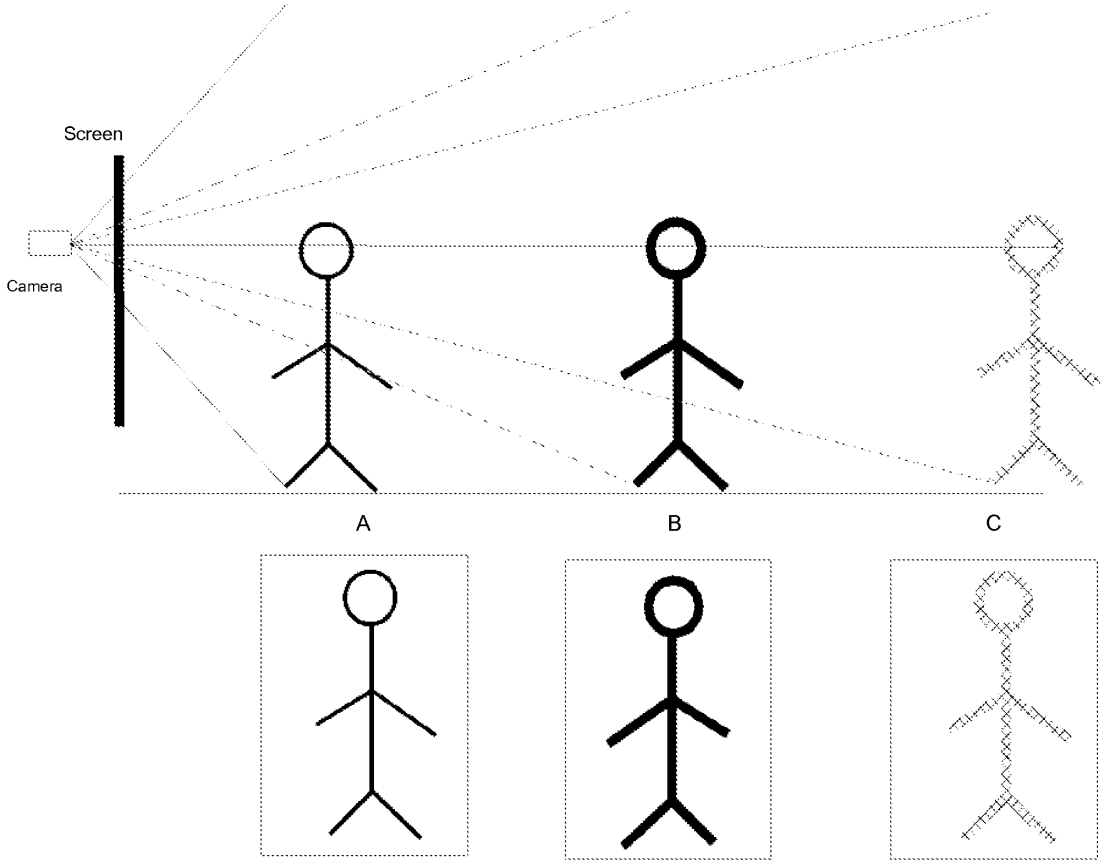


Figure 2 – Ideal setup (a camera or multiple cameras in a vertical array at the user's eye level, to obtain low Image distortion and allow the user to see himself at full/nearly full body size from

any distance. For close distances, one embodiment will be to use an array of cameras and use stitching to reduce image distortion.

The Practical Setup:

In this invention we disclose a practical method to implement the ideal system described above with a fixed mounted camera /cameras located at the perimeter of the screen and facing the user. The main challenge is how to compensate the image distortion adaptively to create similar user experience as we would get in the ideal setup.

Figures 3 and 4 show some examples of the challenges using the practical setup (with the camera not corresponding to the user's eye level):

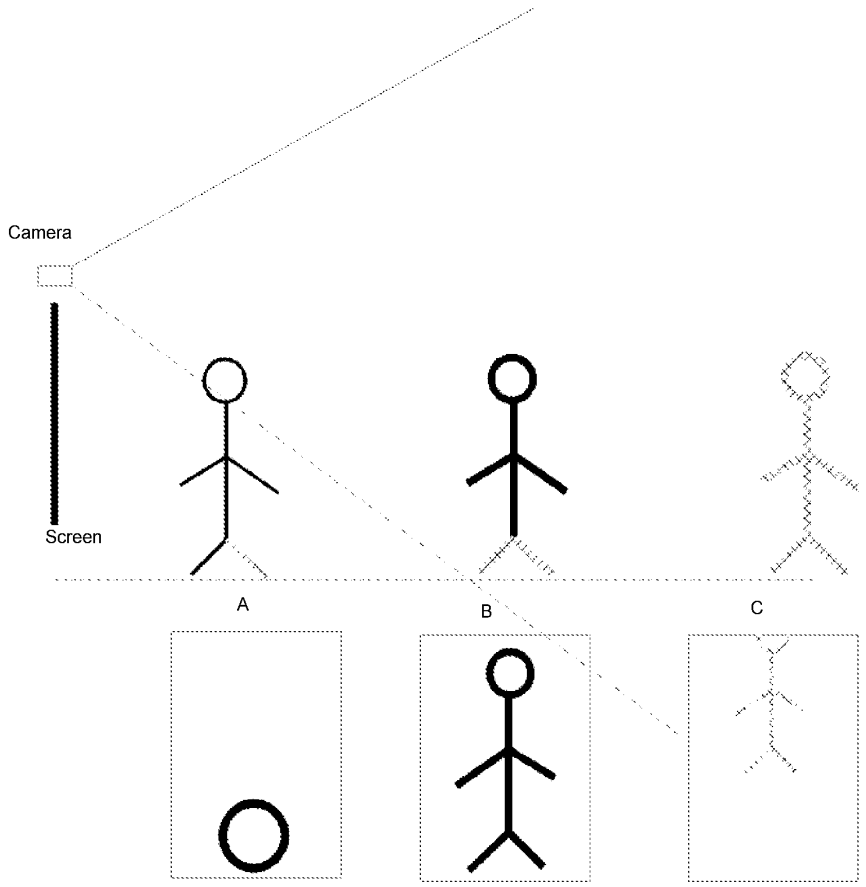


Figure 3 - Camera on a fixed location around the screen perimeter with fixed FOV optimized for distance B.

Figure 3 depicts what happens when the user approaches the mirror or moves away from it when using a camera mounted on the perimeter of the screen. Assuming the system is calibrated to central dynamic range, when the user is far the image is smaller and higher

(scenario C in figure 3) and when the user is close to the screen (scenario A) the image of the user is larger and the FOV of the camera cuts the image of the user. Additionally, when the user approaches the screen, a projection distortion becomes noticeable meaning that the user will not feel as if he is looking at himself.

In one important embodiment, the camera is located at the top of the screen and tilted down to allow maximum dynamic range of the user's movement in front of the screen.

As depicted in figure 4 below, because the camera is tilted the projection distortion is much larger though the effective /usable FOV of the camera will cover a larger area in front of the screen, and will allow the user to get much closer to the screen.

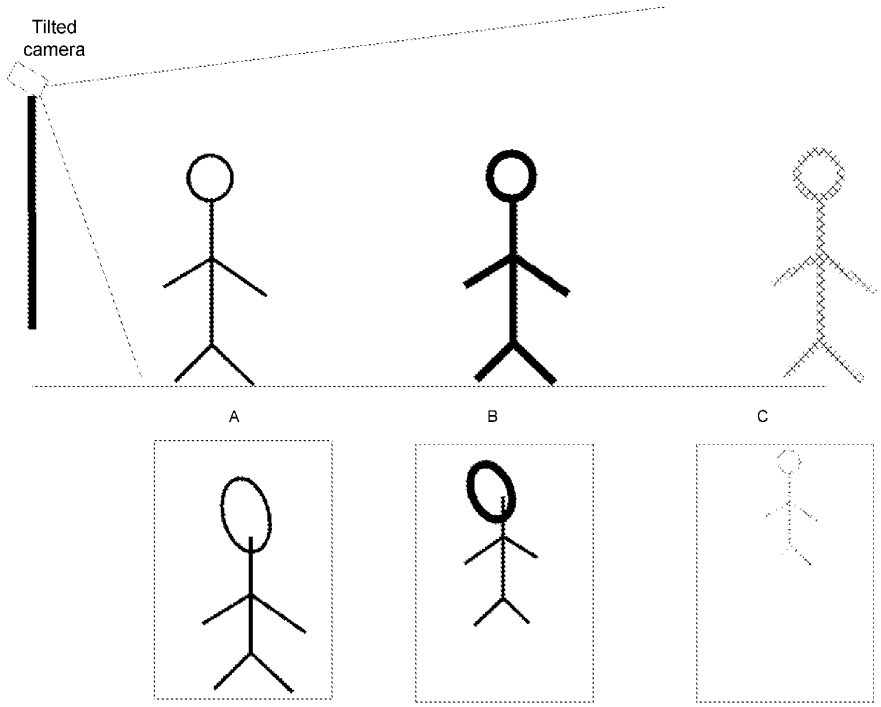


Figure 4 - Tilted camera to allow maximum coverage range

The closer the user is to the camera, the more distorted his image becomes. The nature of the distortion is mainly projection distortion – the user look shorter and the upper body looks larger.

In this configuration the image of the user also got smaller as he was further away from the screen.

In the attached Computerized Method Results presentation you can see the true distortion in this configuration and the level of correction after applying the EyesMatch method.

A more detailed explanation of the EyesMatch method:

We are disclosing a computerized method to generate a convincing (augmented) mirror experience from a camera (located in front of the user and in spatial offset from the screen) and a screen (LCD,LED etc) in real time, and not in real time.

The method corrects the point of view and field of view of the camera to fit with the view point that would occur with a conventional mirror (when the user moves closer or further from the mirror, the view point that would have been reflected in the mirror would have been different).We developed a computerized method with adaptive POV (point of view) and Adaptive FOV based on user tracking.

Attempting to solve the virtual mirror problem by only flipping the image vertically is not sufficient to create a mirror experience; once the user gets closer to the camera /screen the user's image becomes larger, and vice versa, as opposed to a conventional mirror where the user will always see himself roughly at the same size with a bit of a different FOV, regardless of his distance from the mirror. In addition, getting closer to the camera introduces image distortion that needs to be corrected in a much more advanced computerized method.

Important embodiments:

1. Add dynamic adaptive **Image Stitching**: Incorporate multiple cameras from multiple technologies to improve: image resolution, accuracy of the image , extend the FOV of a single camera , reduce distortion for different users and different orientation of user, and create a better model for the user body mesh to compensate the camera's distortion.

Because the image loses resolution as the user moves away from the screen (less pixels on the user), it make sense to optically zoom and refocus the camera. The problem is that it comes at the expense of shrinking the camera's FOV. In order to improve resolution while maintaining FOV, a stitching or dynamic zoom needs to be implemented as well.

2. **Adaptive optical zoom –** Enhance the image/video's quality/resolution, based on distance tracking. The position of the camera at the top of the screen facing down will make sure the FOV is well utilized (as explained in figure 1). In addition, it reduces the asymmetric distortion that can occur if the camera is mounted on the side of the screen.

3. **Delay Optimization** – Optimize the computerized method to reduce delay as much as possible (parallel computing, calculate the transformation per distance offline such that once we measure the distance, the mapping transformation will be ready upfront. We are also proposing a straightforward approach without calibration by creating a projection transformation per user's calculated/measured point of view.

4. **Accuracy of the Image Transportation** - Create a platform that can be calibrated in discrete pointers and the computerized method can interpolate and extrapolate the correct transformation on different positions in front of the screen. Although the projection distortion can be calculated in an analytical way (one of the embodiment is an analytical calculation of the projection based on user tracking and camera location), it is more practical to measure the image distortion in front of the screen, and to use this information instead of direct projection calculation.

The invention has additional embodiments:

1. Single and multiple cameras from all types of sensors including though not limited to: CCD, CMOS, IR CMOS etc., and format protocols: HDMI, Firewire, USB, IP , HDbaseT etc., and any available resolutions: HD, regular SIF,4k,8k etc.
2. Single or multiple screens: regular screens in all sizes, shapes and proportions. Mirror like screens, smartphones or tablets, projectors , hologram, 3D screens, Google glass, HMD head mount display etc.
3. Location of the camera anywhere: Best practice is above the screen looking at the user. Additional locations can be bottom of the screen or on the sides, in case of 3D probably two cameras at the top, side by side, which will provide the best result and ease the computerized method though this is just one example). 3D can also be manipulated from a single camera.
4. The computerized method can cover full body or partial, and different scaling per user selection (e.g. correction of head and/or eyes direction of view/ point of view etc.)
5. The above 1-4 clauses over a still hard copy image 2D/3D
6. The above 1-4 clauses over a still digital image 2D/3D
7. The above 1-4 clauses over analog/digital video that was recorded by analog/digital Camera
8. The above 1-4 clauses over analog/digital/optical video stills that was recorded by frame grabber HDMI(or equivalent) ,IP, USB, Fire wire (Wire or Wireless link)
9. The above 1-4 clauses over digital streaming video that will be delivers to the computing device over (USB, HDMI, IP cat-5/fiber, WLAN, fire wire, HDbaseT, Any combination on single or multiple cable).
10. The above 1-4 clauses when the computing device resides in the camera
11. The above 1-4 clauses when the computing device reside in the screen
12. The above 1-4 clauses when the computing device reside in the cloud

13. The above 1-4 clauses when the computing device resides in a computer (workstation , server etc.)
14. The above 1-4 clauses when the computing device is distributed between the system elements. (e.g. the Computerized method can reside partially in the camera, partially in the video acquisition element partially in the screen GPU (graphic processing unit), partially in the cloud, partially in the user smartphone device or any combination).
15. The above 1-4 clauses when the computing device resides in a smartphone, tablet ,notebook, Screen, camera, HMD, Google glass

Examples of Additional Applications that can Leverage this Technology:

Base video transformation to create reliable virtual dressing.

Base video transformation to create reliable video conference when the user/users on the other side of the line can see you as if you were looking at yourself in the mirror. Or as if you were looking into the camera (e.g. see your eyes pointing at them to the right direction) will provide more live and convincing experience.

Base video transformation for augmented reality for multiple purposes include though not limited (body manipulation and resizing , medical, gaming , dressing, dating, meetings , simulators, dancing, hair dressing , makeup ,training ,traveling etc)

Real time and offline appearance registration and comparison so user can follow up appearance changes over time, over the years. For multiple purposes (medical registration (over time, between multiple exams , multiple/different sensors e.g. for temperature, blood pressure)

Base video transformation for full body signature identification between multiple cameras. (Good when there is not a 100% face recognition). Can complete face recognition and other bio metric techniques.

High level computerized method element description:

Video acquisition – grabbing the video, video enhancement, camera optimization setting and control to get the best video quality under the HW limitation.

Geometric measurements of user orientation: Measure the distance to the user, measure the user height, measure eye position, head pose, 3D body mash estimation etc..

Camera control to set the camera for image/video quality and max resolution. In case of multiple cameras optimization on FOV to get the max resolution will be done based user distance from camera.

Geometric transformation – Takes the video frame by frame, the user geometrical position / orientation and map the raw images to the correct location and fill the blind pixel if there are any.(one of the option as an e.g is to match the eyes as if the user is looking at the mirror. Meaning the computerized method will calculate the right geometric transformation to distort the input video such that the user will look at himself and will feel that he is looking at his own eyes.

Mapping transformation – In order to calculate the correct transformation few embodiments are disclosed.

Scaling approach- Geometric assumption and just scaling correction per distance to match the size of image user would see in a mirror. (Although fixing the size is very important still the feeling is that someone else is looking at you .watching you)

Image projection and scaling approach– based on user distance, spatial offset and (eyes location per distance and offset) we can calculate projection transformation error between user /user-eyes and camera location. We can add other transformation to make it better and to correct optic distortion as well.

Registration approach- Very accurate approach .Will create the transformation based on offline true registration technique of raw image from offset/projected/back oriented camera to an image that was taken in front of the user when the user eyes are staring at the camera. Reference image can be generated from at one camera or multiple camera and stitching (Best practice as example: Reference Camera will be located in a similar height and distance that will reduce most optic distortion 2-3m). The registration will yield the best transformation to match the eyes and the full body based on multiple pointers (preferred location of pointers on a human/ doll like target will be a 2D grid around central body as wide as possible on the legs on the chaste on the shoulders on the eyes etc). To improve accuracy you can repeat this registration for multiple user locations/positions in front of the screen. (Multiple spatial offsets from broadside multiple heights multiple distances etc). . . For each location create the best mapping possible (you can assume multiple distortions (Projection, Burrell, fisheye, or any combination etc) that can be corrected with multiple registration techniques (Projection, Affine, Similarity, polynomial or any combination etc.

Additional computerized method embodiments for further enhancement:

Image stitching – In case of multiple cameras that are located to improve quality resolution, minimize distortion from single camera or increasing field of view . Image

stitching element will be integrated stitching based on user geometric location. (Each camera will have its own transformation correction since the offset relative to the virtual eye location will be different.)

3D IR image can also be registered to the computerized method to allow API for virtual dressing and augmented reality.

Multiple camera to generate 3D view is also potential element to improve the user experience

Quality improvement (Image filtering), for stills or video.(optional using raw files directly from camera)

Augment reality computerized method to change: background, insert objects, virtual dressing etc.

Video Analytic /store analytic to collect information on the user: How many times he smiled, did he enjoy the experience, estimated age, sex, ethnic origin etc, all sort of inputs for behavioral analysis platform that can help to integrate the eComerce into the try-on experience, or as add on to any other application.

Computerized method that can analyze the user try-on item/items and linked it with the shop inventory 3D printing and the eComerce web, eComerce stylist.

Computerized method that can analyze the user body language and linked it with the augmented reality applications, virtual dressing applications, gaming, video conferences etc.

Detailed description and concept block diagrams:

System block diagram

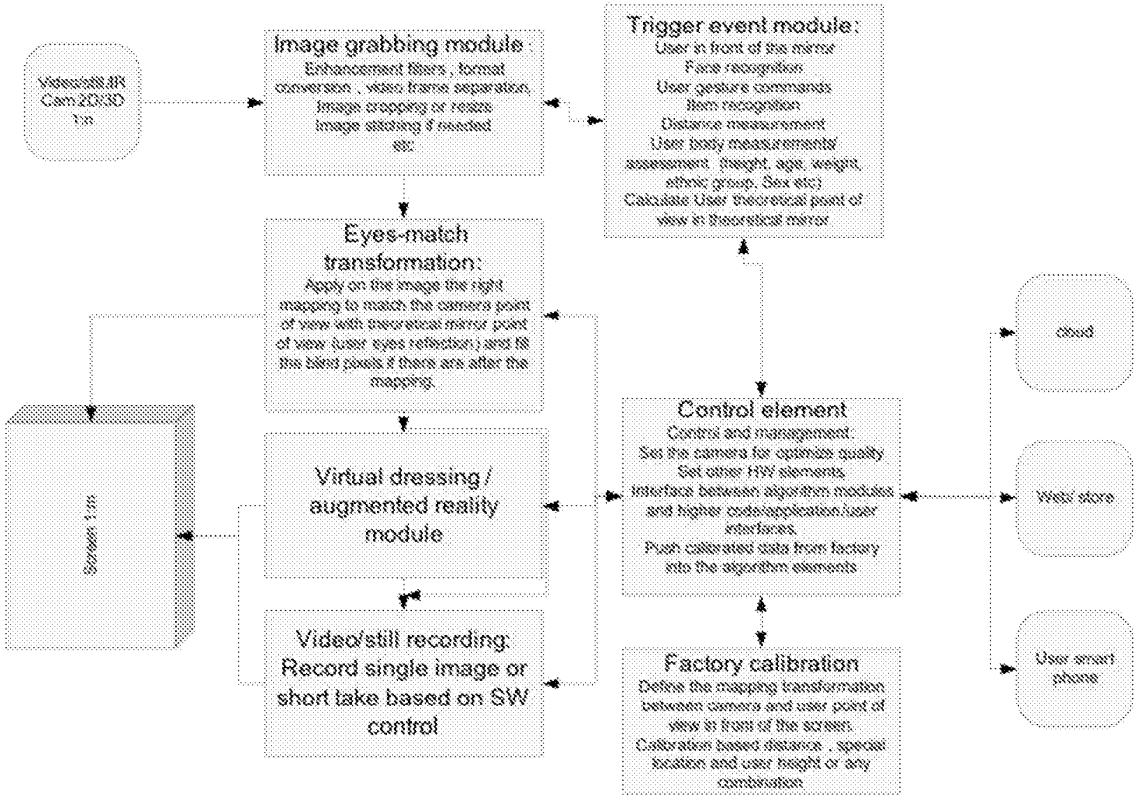


Figure 5 system block diagram

Any modules can be conducted on computer DSP,CPU,GPU, Camera DSP/ASIC, Screen DSP/ASIC, standalone computing device FPGA card, DSP device, ASIC , cloud parallel computing etc.

The functionality of each element can be conducted from other module to optimize computerized method performances.

Camera 1:n streams the images to the image grabber module

Physical media can be for e.g– cat-5, cat-x, fiber, HDMI cable, Wireless (WLAN, cellular) or any other

Video protocol/format can be for e.g. : synchronize/ IP ,HDMI, HDbaseT, Jpeg, Mpegx, H264, analog video,4k, 8k etc.

Functionality of the grabber module:

Capture the streamed images.

Apply filters to improve quality.

Apply cropping or image resize as needed for computerized method optimization.

Apply Image stitching as needed for better quality or wider effective field of view.

Format matching for the computerized method.

Trigger event module – is a parallel process that can get its input directly from the image grabber module though can also get the images after the eyes-match module. The input can be optimized in size and bandwidth and rate to perform the required functionality.

Example of element that can reside in the trigger event module:

Identify that a user is standing in-front of the camera. E.g. based on background subtracting and changes in a predefine zone, pattern recognition, etc.

Measure the distance to the user. e.g. (correlation between stereo camera, 3D IR camera– prior art approach, or our novel single camera measurement that can take some geometrical assumption e.g. (User is roughly standing in front of the mirror and on a flat floor) so the distance, the user height or the user theoretical point of view in a mirror for example can be deduce from measuring the location of the user shoes and the user special offset from the screen broadside ..

Face recognition – to ease the user interface identification. The platform should save the information for each user , and once the user is recognized by the system the system can upload its own Data and save more data for his account suggest items etc. with Face recognition the user don't have to identify himself. Save time and ease the usage.

Video analytic to create meaningful feedback for the commercial computerized method for example computerized method that can estimate age, sex, mood, other popular items etc...

Item recognition so that the system can easily link the try-on into the store. Inventory and eComerce platform for better recommendation and faster checkout + popular items for inventory planning.

Gesture identification for seamless user control

Eyes-match transformation – Get as an input the image from the grabber, in addition the calculated distance or distance and height or actual user point of view.

Calculate the required mapping (can be directly calculated based calculation of the projection angle difference between camera and user theoretical point of view, can be like just matching the required image scale and positioning. Or by a true-match novel approach that utilized factory calibration process to create a very accurate transformation between camera and calculated point of view at discreet locations in-front of the mirror. Or using base images and transformation that created per other (one or more parameters) for example distance, height, pose, according to measurements done in the factory or real time when the user is standing in front of the screen.

Based on user distance and eyes point of view, create interpolation of the transformation at any location in front of the camera.

Since the distance of the user body elements to the camera is not uniform, the projection distortion create effect where closer body parts like the head get more pixels than far body parts like the legs and therefore the user looked with shorted legs and large head. This mapping is not a linear 1:1 (each pixel represent different area length and width(dx,dy) so pixel filling/under sampling will have to be performed to maintain the axis proportion. Filling approach can be any interpolation (near, linear, cubic, polynomial etc.) or more complex filling from different camera projection. (For example Camera from above and below the screen can complement and better estimate the missing pixels or the correct eye orientation).

Additional option is to perform some of the analysis in direct optic (special lens/prism) that will correct most of the projection distortion and will improve the resolution. Some of the resizing issue that affects the quality can also be compensate optically by mechanical zoom.

Virtual dressing , augmented reality module – Get it's input from the EyesMatch computerized method or from the recording module , in addition can get input elements to render from the CPU that maintain an active link with the inventory/ any database/ 3D printing eCommerce data base and can render:

Change item color based on actual try on and available inventory or optional 3D printing on site or in the factory for user customization – main advantage relative to regular virtual dressing is that the item sits on the body as it would have in reality. Very important from many aspects ... User can feel how the item feels on his body, how it may effect and change his body shape etc.

Adding accessory or true virtual dressing capability to the platform

Augment the background to change or create different environment.

Video/stills recording module – gets its video/stills from the camera grabber directly /or from the EyesMatch module or from the virtual dressing augmented reality module. In

addition gets control from the Control module that indicates when to start / stop recording, and what information to store per user, and on what video/stills to process off line additional transformation /augment reality/virtual dressing/quality enhancement computerized method.

Control element – The platform glue between all the elements :

Configure all the HW elements, computerized method modules in the system including the cameras, screen , DSP etc

Conduct the main platform code to support the user needs.

Link between the local station and the cloud base eComerce, other web application, smartphone application etc. The information that will be recorded on the mirror station can be deliver to the user immediately by wireless signals / IR/ wire or can be delivered by the user authorization to a cloud base application like (Facebook google or other) or to the company server that can be linked to the eComerce application.

Factory Calibration module – The camera to screen geometry orientation can be determined/ measured in the factory, or can be measured in the field and offset can match the calibration with the factory condition; in addition correction can be match to height or angle of the mirror setup relative to the floor.

Create Mirror reference of how the image should look like in the mirror at different discrete distances, special orientation, different eyes reflection location (Theoretical point of view). The reference can be taken in multiple ways:

1. Locate camera at user eye height or close to and when the user/doll with pointers is standing in a distance that will eliminate most of the camera distortion looking at the camera. The scaling of the image can be match and cropped to represent true size or slightly smaller .(dx,dy) of the reference image should match true size of the user on the screen or smaller to fit the screen if preferred (depend on the size of the screen)

2. Take the reference by standing in-front of a conventional mirror with doll, target or actual user with pointers and camera located at eye level.

3. Reference image can also be performed with array of multiple cameras in front of the user in a vertical line to eliminate distortion and a stitching of the images to get a uniform image with high resolution and low distortion.

Google glass can also be an option for calibration in this scenario. The user/target with the camera will take a picture of himself in-front of a regular mirror. (since the FOV is fixed only thing that need to be done is resize the image for true size

At the same theoretical point of view take a picture from the actual projected camera /cameras.

Registration of both a,b (automatically or manually by locating pointers on the target for calibration (can be a user or a doll or a target board). From the registration information extract the transformation that can best bring the distort image to the right eyes and body orientation.

Based on actual installation geometry add offsets or correction to the transformation.

Based on user distance and eyes point of view, create interpolation of the transformation at any location in front of the camera .(This part can actually be done under the EyesMatch computerized method as well see 3b)

Additional comments:

Screen format - the computerized method can wrap the video and push the screen at the available format e.g. HDMI 21:9 is a good standard to support standard mirror proportion between height and width. Or at any other format for different usages

You can repeat on 1:7 for each eye to create 3D effect (assume the screen support it in a vertical orientation.

Suggested claims elements:

Generic claim real time mirror

a. Video grabber

b. Trigger event

c. Image process transformation (Adaptive /semi adaptive EyesMatch computerized method approach as described figure 5,6).

d. Active screen as a mirror

Embodiments for Generic claim 1

Same as 1 though c. can be enhance EyesMatch as described in Figure 9

Same as 1 though c. can be just scaling per distance

Same as 1 though c. can be direct calculation without factory calibration (Assume protective distortion or other analytical distortion that can be compensated based on user tracking.

Same as 1 though a. can be multiple cameras with image stitching based on EyesMatch computerized method approach.

Same as 1 as a platform for virtual dressing or augmented reality (Background can be switched , user can be dressed with selectable items , item can change color accessory can be added)

(True virtual dressing changing just colors / textures of items or traditional virtual dressing that render items on user body)

Same as 4, when 3D IR camera can be used to improve the virtual dressing and colors changing by better define the user orientation body line etc.

Same as 1 when 3D IR camera can be used in the registration process to better match and correct the camera distortion, and better measure the user orientation in front of the screen.

Same as 1 + complex stitching based on user point of view and location in front of the screen

Same as 1 + video analytic to better utilize the shop inventory and planning and the eComerce platform (as described above).

Same as 1 with additional computerized method for eyes orientation correction based on had pose detection and eye restoration

Same as 1 with additional computerized method to correct other optics distortions.

Same as 1 with enhance registration (reference image can be combined from stitching images to enhance resolution and to reduce optic distortion, or Reference can be performed in multiple offset user highest and spatial offset from broadside to better handle multiple distortion effects.

Same as 1 though the screen to show the video can be located in remote location and the local screen can show image of the remote user for EyesMatch video conferencing.

Generic claim switchable mirror screen (based on photovoltaic controlled multilayer glass that can change the reflection coefficient between transparent, obscure or mirror (reflection close to 1) by applying voltage potential to inner layer e.g. PDLC glass on top of a screen. (Main advantage is that we don't need HW DSP to conduct real-time mirror, the computerized method can run offline on the recorded video/stills.

Video grabber

Trigger event

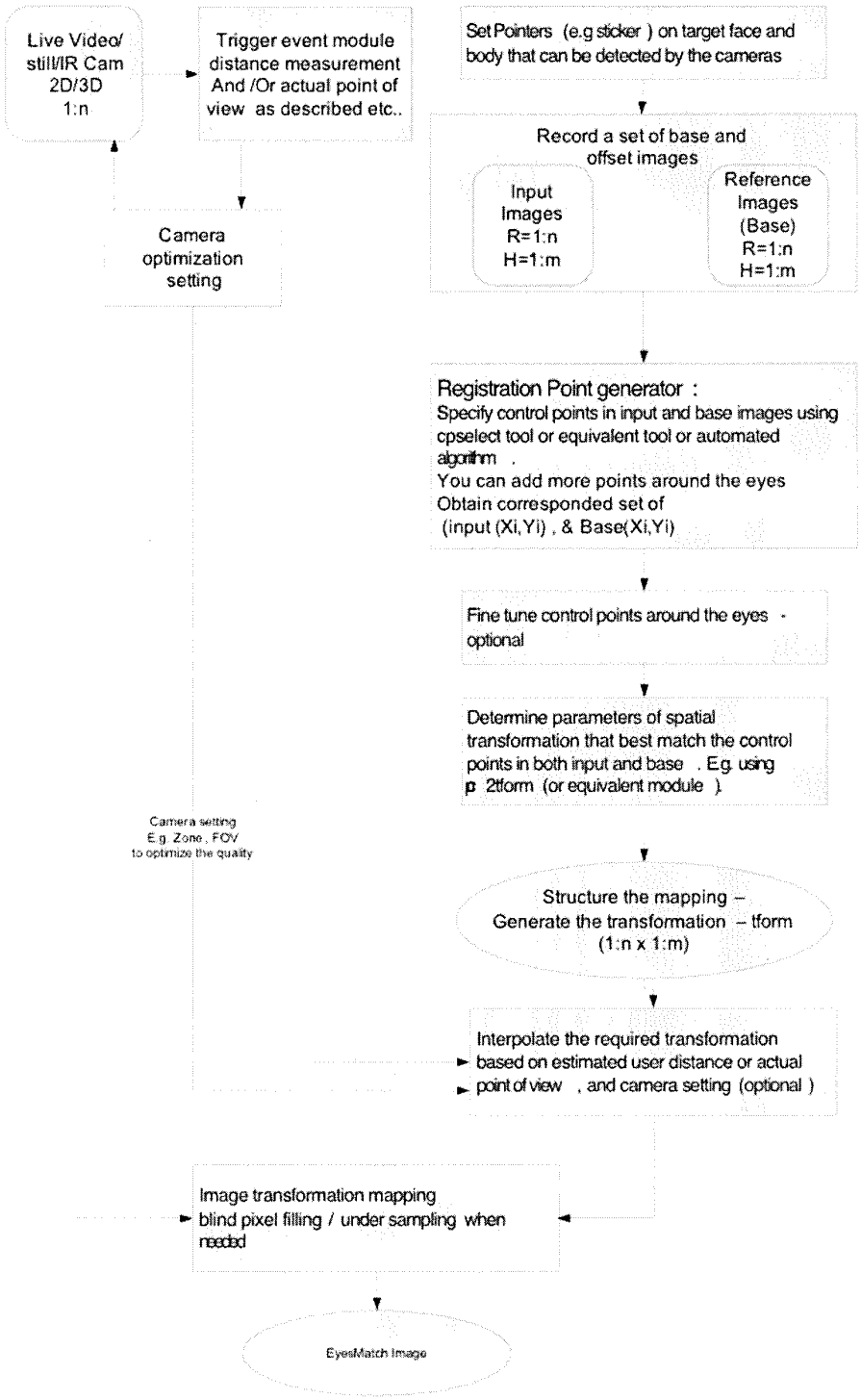
Image process transformation (Adaptive/semi adaptive EyesMatch approach as described in figure 5,6)

Switchable glass (one state as a mirror) second state as a Screen that can show the records video files as a mirror.

Embodiments for Generic claim 2 : same as for generic claim 1

Implementation of computerized method block diagrams

EyesMatch computerized Method – Figure 6



High level explanation for one embedment scenario as an example:

1. Factory calibration procedure:
    a. Create a target doll/user/board target for calibration ,
    b. Allocate pointers on the target
    c. Mount the camera above the screen, tilted down as described in Figure 4. Capture the maximum range.
    d. Input Images- Take a snap shot of the target at multiple locations (distances, heights , literation offsets). For simplicity just multiple distances along the central virtual line in front of the screen will do
    e. Reference Image -Take a snapshot of the same target with the allocated pointers at a reasonable distance to avoid camera distortion. Resize the image to represent true size on the screen. You can take multiple references at multiple distances to capture the small changes when user approaching the mirror or just one.
    f. Using the pointers registered the distorted images that were taken from the tilted camera to the reference image that represented how the user should look at a mirror. The output of the registration is set of pointers etch has two coordination one in the input image and one in the reference image.
    g. Find the best transformation that will apply the input pointers into the reference image.(multiple distortions function can be apply to get the best matching performance , principle one will be projection and resize)
    h. Create mapping transformation for etch calibration point.
2. Grab the live video
3. Measure User location /user point of view (based on the proposed method or based on other sensors like kinect) and interpolate the factory calibrated mapping to create the correct mapping for the user location in front of the screen.
4. You can add scaling factor to the interpolation to match screen size and user height.
5. Apply the transformation mapping on the live/recorded video
6. Fill in the missing pixels by interpolation technique.

Comments – Figure 6:

For 3D will need to implement the computerized method above for two cameras at a distance D. The transformation will be calculate from registration the input camera at a distance D with two reference (base) camera at a spatial distance that is similar to the distance between to user eyes.

In order to improve the base for registration we can take Kinect or any IR 3D camera as a reference /base or as additional base so the actual mapping can be much more accurate since due to the 3D capability there will be less distance error for organs like ears or nose, shoes etc. (pointers should be detected by the IR 3D sensor of the kincet)

Google glass can also be an option for calibration. the user/target with the camera will take a picture of himself infront of a regular mirror. (since the FOV is fixed only thing that need to be done is resize the image for true size.

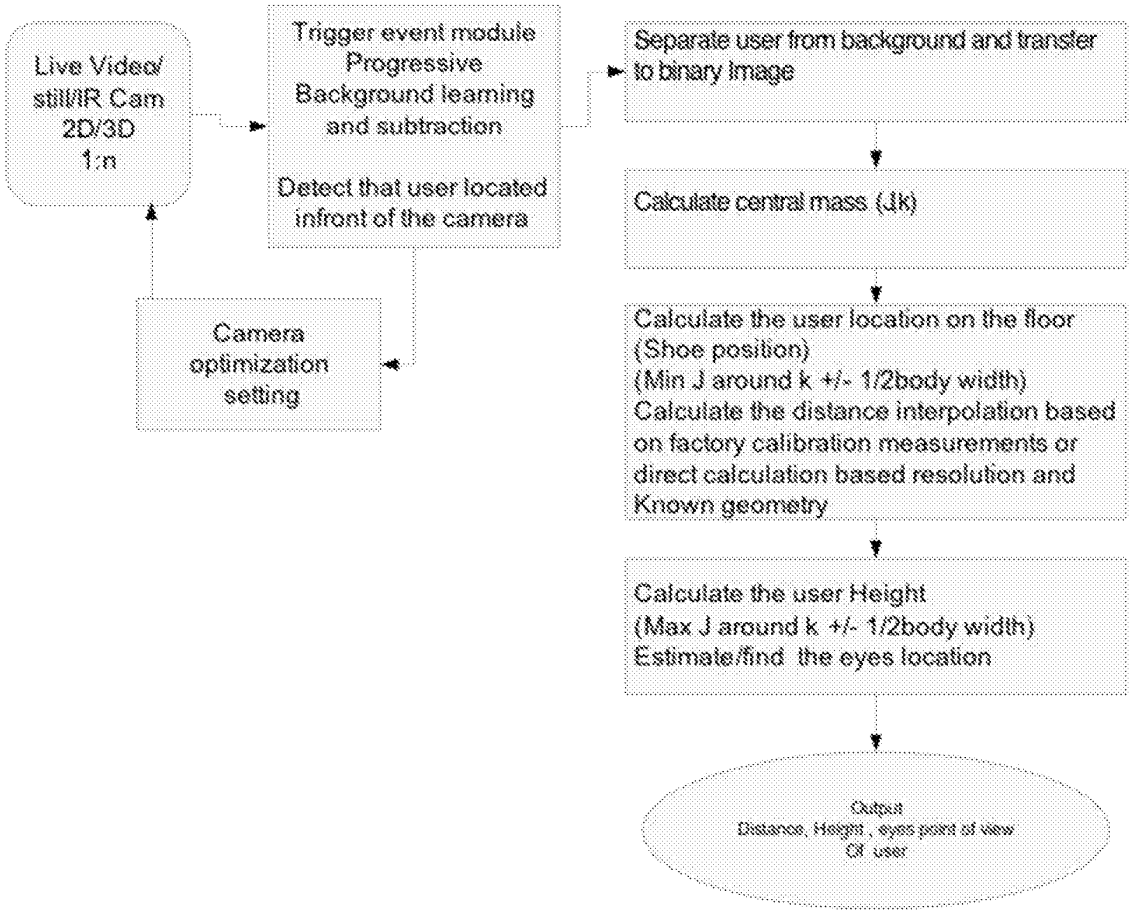
The Image transformation module can also apply Image resize for zoom in /out to allow the user to fit the image to the screen or to focus on some part.

To address some of the scenarios direct calculation of the distortion between camera and theoretical user point of view can be calculated and ease the need of factory calibration and heavy registration procedure (e.g. assume we correct just the projection error we can create analytical mapping transformation between the cameras.

The image base for registration can be taken using camera at various distance from user or fix distance or image from passive mirror as is and multiple pointers on a target. The target for calibration can be any XY multiple pointers better have more than 4 for at least correct projection distortion though preferably much more. Calibration can be focus on head (per height) give different weight to the pointers.

The measurement of the base and input for registration can be taken simultaneously for better accuracy or at different setup and different timing (as per the example will show in the computerized method result presentation)

Single Camera Distance measurement – Figure 7



Comments- Figure 7:

When the camera located above the screen and pointed down. It can see the user shoes from 1m to 4m easily. Problem is that the distortion is at the maximum. With the EyesMatch computerized method we can show a compelling distortion improvement at all distance.

Other technique can be implementing to separate the user from the background e.g. use the IR camera.

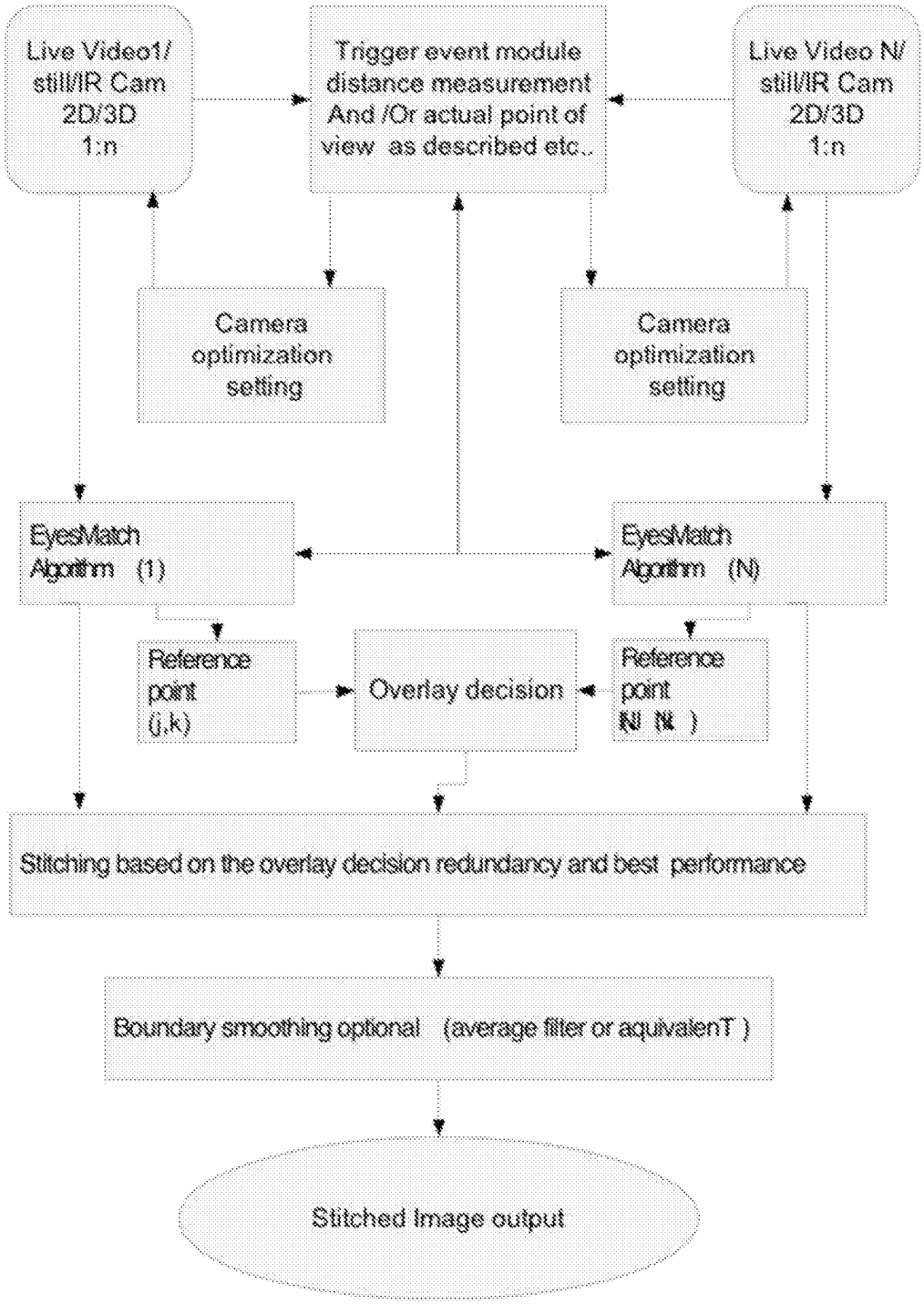
This method is much faster than 2 camera stereoscopic measurement due to the minimal effort in the image acquisition and the image correlation to measure the pixel distance.

Finding the central mass is done by multiply the binary image by index matrix and summarize and mean the pixels index.

Finding the min body pixel below central mass (J,k) is done by opening a window around k (central mass) and finding the lower active index that represent the shoes.

Calculating the height is a bit more difficult since the image is distorted – we actually finding the top of the head and based on the distance camera resolution FOV and the camera geometric tilt we can estimate the user height.

Adaptive stitching- Figure 8:



Comments- Figure 8:

Motivation for stitching is to improve Image resolution and FoV once user is approaching the screen. 1:N cameras can be stitched together.

Every camera will go thru different geometrical transformation since the location and orientation of the camera are different then relative to the user point of view

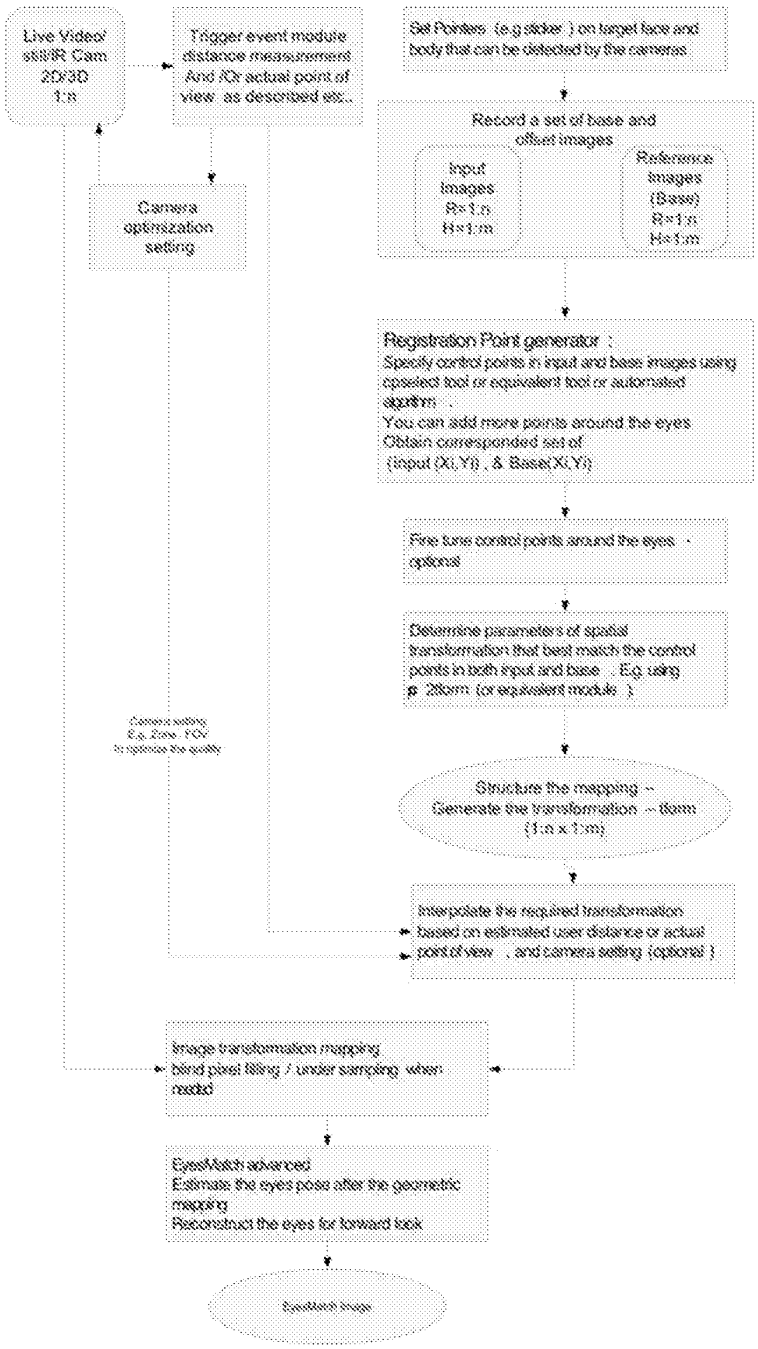
For maximum performance the stitching need to be optimized based user distance from the cameras

Smoothing is needed to filter out the line that can be obtain since the image absolute quality and difference in lightning and distortion correction will be slightly different between the different cameras .

Additional technique for smoothing can be interleaved between the images on multiple rows to ease the lighting affect.

Overlay decision is the decision element to determine where will be best to perform the stitching. If we are dealing with scenario with two cameras one located above and one below the screen the overly decision will indicate the index of the best cut. Since we have distance measurement constantly it is possible to maintain the stitching line almost fixed once user approach the mirror.

EyesMatch Advanced – Figure 9



Comments – Figure 9:

The additional advanced EyesMatch element will improve the quality of the eye steering experience. (because in some geometric scenarios especially very close to the screen the geometric registration correction can be improve)

The idea is to override the eyes zone or just the eyes with modified pixel that will create the feeling of Broadside view.

The element in this module is first locating the eyes in the image and make sure that the user does look at the screen (since the scaling is already correct all that we need at this stage is to fix/reconstruct the internal eyes elements e.g (pupil, iris etc).

The information for the advances correction can be deduced from history image, estimated for regular statistical eyes proportion or actual measurement once the user look at the camera or once the user is standing far enough from the screen where the distortion is relatively low after the geometric mapping of EyesMatch element.

The Image transformation module can also apply Image resize for zoom in /out to allow the user to fit the image to the screen or to focus on some part.

Computerized results examples

Enclosed in a separate presentation file.

The presentation shows the performance of the EyesMatch computerized method before and after at various distances relative to original image.

In addition it shows example of the computerized method results after applying Image resize (reduce by 20%) to allow the expansion of the view on the screen (If the screen is smaller like in this example than full body resize can be very useful to see the entire body).

This technique can also increase the image size to focus on body parts.

Electronic Patent Application Fee Transmittal

Application Number:	
Filing Date:	
Title of Invention:	VIRTUAL MIRROR
First Named Inventor/Applicant Name:	Nissi Vilcovsky
Filer:	Joseph Bach/Monica Moreno
Attorney Docket Number:	067055-002099

Filed as Small Entity

Provisional Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Provisional Application filing fee	2005	1	125	125
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
			Total in USD ($)	**125**

Electronic Acknowledgement Receipt

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Application Number:	61738957
International Application Number:	
Confirmation Number:	1073
Title of Invention:	VIRTUAL MIRROR
First Named Inventor/Applicant Name:	Nissi Vilcovsky
Customer Number:	46188
Filer:	Joseph Bach/Monica Moreno
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Attorney Docket Number:	067055-002099
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Time Stamp:	19:55:33
Application Type:	Provisional

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$125
RAM confirmation Number	7923
Deposit Account	503557
Authorized User	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)

1	Application Data Sheet	067055_002099_ADS.pdf	1442705 02bb0f394faf8ac8553ea5bc0939cfac8c082be5	no	6
Warnings:					
Information:					
2	Specification	067055_002099_Provisional_Application.pdf	673369 149dcfc050ceed20e86c63e2bcb48c4f45a4bd0b	no	28
Warnings:					
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3	Fee Worksheet (SB06)	fee-info.pdf	29383 b7db36afc995a7afbc1160afb5c6b5ccb51c2750	no	2
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CONFIRMATION NO. 1073

FILING RECEIPT

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OC000000058481356

Date Mailed: 01/08/2013

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Projected Publication Date: None, application is not eligible for pre-grant publication

Non-Publication Request: No

Early Publication Request: No
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Title

VIRTUAL MIRROR

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