Walking through Sight: Seeing the Ability to See, in a 3-D Augmediated Reality Environment

Ryan Janzen, Seyed Nima Yasrebi, Avishek Joey Bose, Arjun Subramanian, Steve Mann
Department of Electrical and Computer Engineering
University of Toronto

***Abstract*—A 3-dimensional augmediated reality (AR) environment was designed, where users can physically walk through space, and by looking through AR glasses can see and interact with hidden veillance flux produced by cameras. Surveillance cameras, physically attached to a room, as well as handheld and body-worn cameras, each emit veillance flux and have a veillance field — a mathematical formulation of their capacity to see, as that capacity to see propagates through space.**

In this work, for the first time, we bring the mathematical veillance field into 3D augmediated reality, to "see sight".

I. Introduction

Recently we introduced *veillance flux* and the *veillance field*, a mathematical formulation to account for the *ability to see* as it propagates through space from a camera [1], [4].

An intersecting web of veillance field lines and veillance flux, ordinarily hidden in the world around us, is "emitted" by various surveillance cameras, sousveillance cameras (*e.g.* body-worn cameras [2][3]), and embedded vision on hands-free doors, faucets, and lighting systems.

The first measurements of the veillance field employed a laser-scanning method, to quantify the ability to see, as it propagated through space from cameras [1]. *Bio-veillametrics* and *bio-veilluminescence* were first accomplished in [4], revealing the 3D veillance field emitted by a human eye. In this new work, we visualize veillance fields from cameras in real-time, to make seeing visible: to "visualize vision" and "see sight."

II. Seeing and measuring sight: Initial calibration of the AR environment

AR setup involves the placement of cameras and the initial test and measurement of their veillance flux. We employ a combination of dome-enclosure cameras, bracket-mounted cameras, and handheld cameras operated by users.

To first detect veillance flux emitted by those cameras, we use a combination of *veillametrics* [1] and field-of-view detection based on an array of LEDs with a video feedback loop, in a "video bug sweeper", analogous to the audio bug sweepers used to detect hidden microphones [4]. Abakography [5] is then used to render a 2D visualization if desired (*e.g.* Fig. 1a). Finally, to prepare for AR rendering, veillance flux emitted by each camera-under-test is vectorized, by marking its edges using a handheld marker beacon and a 3D depth sensor.

III. Egographic and Extrographic Augmediated Reality to Visualize the Veillance Field

Rendering veillance flux in 3D, as well as marking and tracking it spatially, is performed in our system using both egographic (body-mounted, outward facing) depth sensors, and extrographic (environment-mounted) sensors.

For an egographic sensor we use the 3D depth-sensing Meta 1 glasses (worn on the head to track camera/beacon positions), which also serve as a see-through AR display.

For an extrographic sensor, we have two implementations: one design uses a tablet computer programmed to optically recognize and track the motion of cameras-under-test directly for deducing the motion of veillance (Fig. 3); the other design uses a stationary 3D camera to track users' bodies in absolute position. The relative position vector from the egographic sensor is added to the absolute position vector from the extrographic body sensor, to give a final absolute position, during the calibration stage and during the real-time AR experience when tracking stationary and moving cameras.

Once veillance-field calibration is complete, the AR experience can begin. Veillance emissions from cameras are visualized along with markup statistics (Fig. 3). Users can also point their own head-worn cameras at others to photograph them (*i.e.* to "shoot" a photo and emit veillance flux). The system tracks the position of the head-worn cameras using the inertial measurement unit (IMU) in each set of Meta glasses.

Augmediated reality (AR) veillance flux is rendered though each user's AR display from the perspective of his/her current position, rendered stereoscopically using Unity3D, orienting in space in real-time through a combination of IMU readings and optical tracking.

IV. Further information

Video demonstrations can be seen at:

`http://veillametrics.com`

References

[1] R. Janzen and S. Mann, "Veillance flux, vixels, veillons: An information-bearing extramissive formulation of sensing, to measure surveillance and sousveillance," *Proc. IEEE CCECE2014*, May 4-7 2014, 10 pages.

[2] S. Mann, J. Nolan, and B. Wellman, "Sousveillance: Inventing and using wearable computing devices for data collection in surveillance environments." *Surveillance & Society*, vol. 1, no. 3, pp. 331–355, 2003.

[3] V. Bakir, *Sousveillance, media and strategic political communication: Iraq, USA, UK*. Continuum International Publishing Group, 2010.

[4] R. Janzen and S. Mann, "Veillance dosimeter, inspired by body-worn radiation dosimeters, to measure exposure to inverse light," *Proc. IEEE GEM2014; to appear, 3 pages*, 2014.

[5] S. Mann, R. Janzen, T. Ai, S. N. Yasrebi, J. Kawwa, and M. A. Ali, "Toposculpting," *Proc. IEEE CCECE2014*, May 4-7 2014, 10 pages.

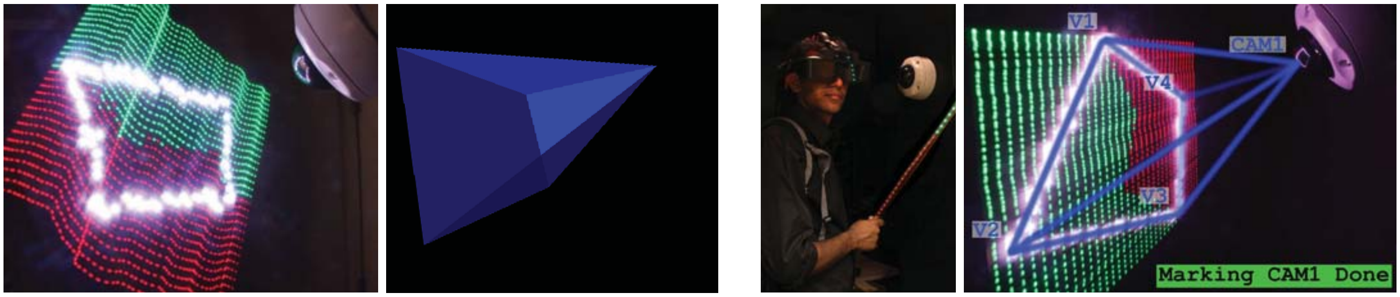

Fig. 1. Augmediated Reality rendering of veillance flux: (a) Raster representation of veillance flux [1] from a security camera, detected in 3D by combining veillametrics [1] with abakography [5]. (b) Vector representation of veillance field, rendered in 3D for real-time augmediated-reality (AR) visualization of invisible veillance fields as a user (c) walks through them in physical space. (d) depicts the veillance vector markup process, completed while setting up the AR environment.

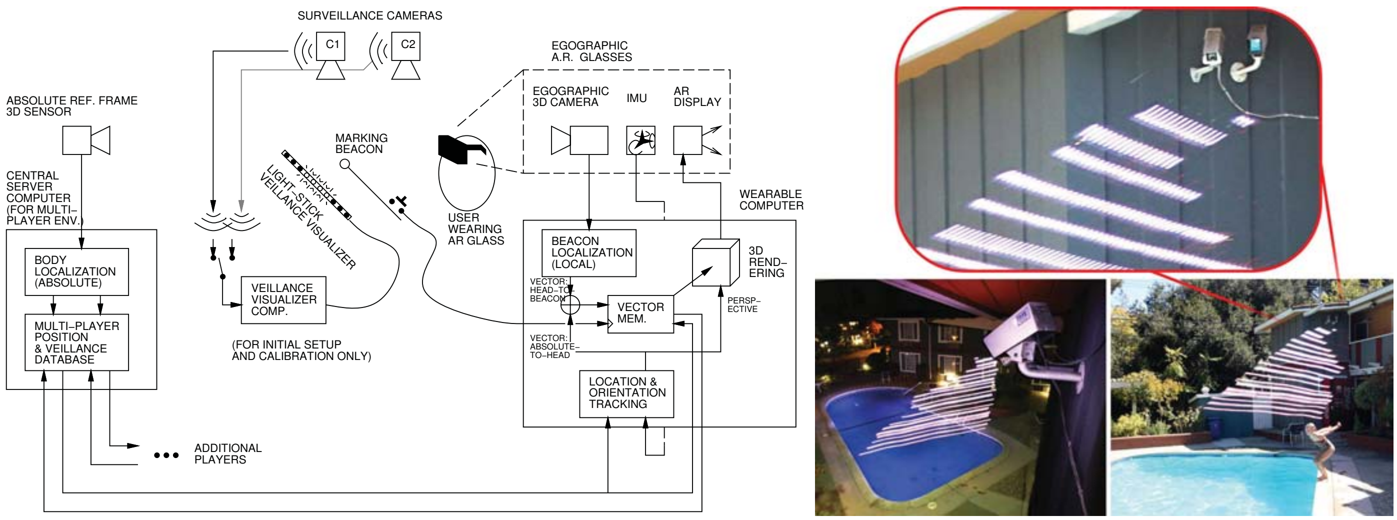

Fig. 2. (LEFT) Generalized signal flow of Veillance Augmediated Reality based on vision and IMU (inertial meas. unit) data, to be able to track cameras and participants' bodies for perspective rendering. (RIGHT) Veillance flux 3D perspective rendering, using experimentally-measured data from the light-stick veillance visualizer (shown in diagram) measured at night and re-rendered the next day from a different perspective using image-based rendering (IBR).

Fig. 3. Real-time augmented reality to see veillance flux, where the system is overlaying statistics about veillance flux from two different cameras.

Fig. 4. Progressive capture and marking of veillance field, in order to set up the game and begin the AR experience of veillance. This figure illustrates a methodology to create vector renderings of the veillance field border, as opposed to our other methods that display a raster abakograph of veillance flux.

978-1-4799-7546-4/14/$31.00 ©2014 IEEE