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Keynote – Eye Itself as a Camera: Sensors, Integrity, and Trust

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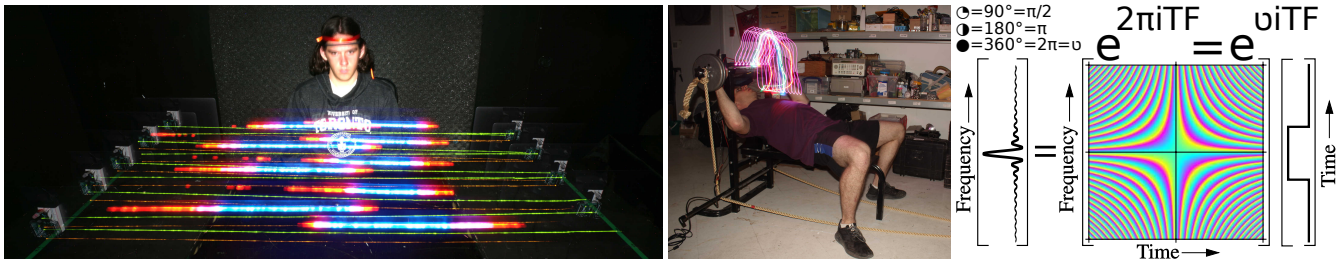

Figure 1: Integrity-of-completeness: (Left) Capturing brainwaves causes the human eye itself to function as a photographic camera (blue=maximum vision; note hysteresis). Prohibiting photography will become totally absurd! Surveillance is a half-truth without sousveillance. (Center) Kinematics (distance and its derivatives: speed, acceleration, jerk, jounce, ...) is a half-truth without also including integral kinematics, i.e. time integrals of distance. (Right) Pi is a half-teth (π=180°), whereas the Phoenician/Hebrew/Arabic/Oscan letter ʊ, teth, means "wheel", "bowl", "circle", "sun" or "disk" and defines the whole 360°.

ABSTRACT

Ayinography is the use of the eye itself as a camera. By recording brainwaves, we read the "mind's eye". Wearable ayinographic technology represents a new opportunity to solve an old problem: the lack of integrity inherent in the world around us. We live in a world of half-truths where incomplete evidence is collected about almost every facet of our lives. Wearable computing can and should provide the answer that allows us to capture and tell our own story, in a way that builds trust and integrity in service of truth, and ultimately, service of humanity through extended-reality intelligence (Human-in-the-loop AI). More generally we advocate whole truth through a full panoramic 360° wearable vision system (Teth Vision™), and a complete understanding of fundamental physics through *Integral Kinematics*.

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1 SENSORS AND INTEGRITY

Surveillance, as a professional practice, often involves secrecy: governments and corporations often wish to hide the function and purpose of their cameras. Cameras are often concealed behind darkly smoked acrylic domes that also contain metal shrouds to conceal the direction in which they are pointed, giving them a full 360° concealed gaze.

Wearable computing is a unique form of sensing in which, typically, the sensors are under the purview of an individual wearer. But many business and government establishments forbid recording by individuals. This is problematic for individuals who use wearable computers to help them see (e.g. wearable cameras) or remember (e.g. visual memory prosthetic [Mann 1996]). We're developing technologies that make the human eye itself function as a camera. This raises an interesting philosophical question: if the eye itself is a camera, and cameras are forbidden, we absurdify the hypocrisy of "no photography" in our highly surveilled society.

Surveillance without sousveillance is a half-truth in which one party captures and records evidence while (1) destroying evidence captured by other parties, or (2) equivalently forbidding other parties from capturing their evidence in the first place (Fig 2).

"Integrity" is a Latin word from the same root word as the word "Integer" or "Integral", meaning "intact", "soundness", "wholeness", and "completeness".

In order to exhibit integrity, an environment of completeness must be possible. A system where institutions can freely engage in surveillance whilst forbidding sousveillance is not a complete system, and is thus a system of half-truth – devoid of integrity. To remedy this issue, individuals' freedom to exercise sousveillance must be guaranteed as a basic human right, i.e. ownership of one's own senses, including one's own EVG (Electro-Visuo-Gram). The EVG (phase-coherent detection of EEG from vision) can be used to construct an image – the ayinograph.

2 EYE IS A CAMERA

Veillance gives a complete picture when we have both surveillance and sousveillance. The ultimate sousveillance is the point-of-eye (PoE) recording we're developing (Fig. 3). Since the eye can function as a camera, we track the eye's position while using a lock-in amplifier referenced to room-light flicker in order to measure how much a person can see (i.e. pixel value) for each direction of gaze.

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Figure 2: Surveillance is the veillance associated with the authority to prohibit other veillances, i.e. surveillance is the veillance of hypocrisy. The opposite of hypocrisy is integrity. Our wearable computer photographed Chinese text to translate it into English, yet it would appear that translation devices (as well as devices to make signs audible to the blind) are forbidden. "您已进入图像采集区域" = "You are under surveillance"; "禁止拍摄"= "Cameras prohibited." We also argue that the human eye can function as a camera, and that being able to remember what we see is a fundamental right AND responsibility (e.g. to testify in court about what was seen).

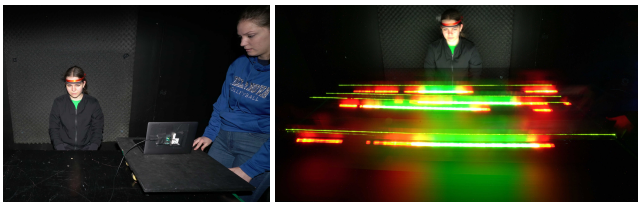

Figure 3: Co-author Christina is the subject of this "Mind's Eye" experiment operated by co-author Megan who moves a roll-cart back-and-forth. On the cart is a Macbook® displaying a subject-facing flashing checkerboard pattern. A lock-in amplifier referenced to the pattern is fed by an InteraXon™Muse with OpenBCI occipital electrode. The amplifier drives a multicolored LED, allowing us to photograph the eye's capacity to see. Green indicates maximum veillance flux. Exposure time 8 minutes at f/22, ISO 100.

3 INTEGRAL KINESIOLOGY

Another example is in kinematics. The field of kinematics typically considers distance or displacement, x, and its time derivatives, $(d/dt)^n x$, $n > 0$. Integral kinematics includes integrals, i.e. n can be positive or negative (for $n = -1$, we have absement, $n = -2$, absity, and so on). There is logic in using absement (time integral of distance or displacement) and the time integral of momentum (which we proffer to name "momentement") as state variables.

Integral Kinesiology is a program of physical fitness based on principles of absement and momentement, in which we also propose complex-valued resistance training, as shown in Fig 1 (center). Here we have a bench press with mass (weights), springs, and friction (connected by cables, ropes, and cords). In our opinion only the friction (e.g. fluid damping) component should be called "resistance training" as the mass and spring should be considered "reactance training". Together we have a generalized complex-valued resistance training modeled as an electric circuit, together with tilt and position sensors and wearable sensors that provide real time feedback on how to do the bench press with proper form.

Our fitness training system accounts for 3 kinds of complex-valued resistance: (1) movement against a mass' gravitational attraction to the earth ("capacitance training"); (2) movement against a spring ("inductance training"), and (3) movement against a damping device ("resistance training"). This triad of impedances creates a more diverse workout.

4 PI IS A HALF-TETH (π = ʊ/2)

Human vision has a roughly 180° field-of-view. Pi is a mathematical constant equal to the circumference of any circle divided by its diameter. Its symbol, π, appears in many mathematical formulae. There is even a day, March 14^{th} (3-14) called "Pi Day", founded at the Exploratorium in 1988. Since π=180°, it is really a symbol that represents half a circle. So we propose the use of the semicircle symbol "◖", instead of the symbol π. We also propose the full circle symbol ⊗ or ⊙ to denote 2π. Thus we write: ⊙=360°.

The Greek letter theta, θ, originates from the letter teth. Teth is a letter found in the Phoenician, Paleo-Hebrew, Arabic, Oscan, Western Greek, Etruscan (ancient Italy), Gothic, and old English[1] alphabets, and also as the "Sun cross" solar symbol[2]. The letter teth is written as ʊ. It is also written as ⊗, ʘ, ⊗, or þ, and means "sun", "wheel", "cauldron", "pot", "pan", pie plate, or circle (complete circle), and in some fonts actually looks like a wheel with four spokes or a circle with all four quadrants present. Thus we propose using teth as a quantity equal to 360°. We propose Jun28 (06.28) as Teth Day (www.tethday.com), and Jun21-28 as Teth Week to celebrate wearable full 360° panoramic vision. Join us today (Jun21=date of publication) and every year thereafter, to celebrate Teth Week.

5 BIOGRAPHY

This paper is the result of work by many people, so here's our organization's biography: MannLab Canada, at 330 Dundas Street West, in Toronto, is the birthplace of many successful companies such as InteraXon, makers of the Muse (wearcam.org/interaxon.htm). Wearable computing also originated in the Toronto area in the 1960s and 1970s, along with many other inventions like HDR (High Dynamic Range) imaging (http://wearcam.org/hdr.htm).

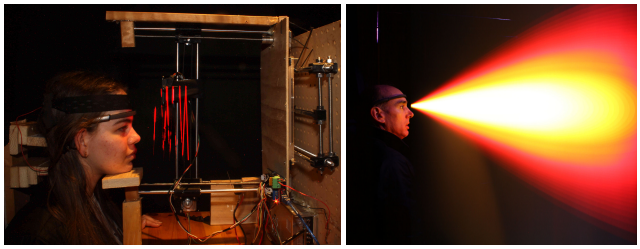

Figure 4: Left: Ayinograph of MannLab member Christina, captured with mechanical prototype. Head is stablized by wooden blocks behind it, and under chin, while stepper motors move a brain-modulated light source through space. Eventually the apparatus will be miniaturized into a wearable device. Right: Interpolated ayinograph™ of MannLab member Steve. Sparsely sampled SSVEP data is interpolated to make the high-resolution ayinograph.

[1] As the letter "hwair", and later as the letter "thorn"
[2] Compare with the Chinese character "日" which means "sun", or "回", meaning "round", or "口", meaning "mouth".