Telepointer: Hands-free completely self contained wearable visual augmented reality without headwear and without any infrastructural reliance *

Steve Mann; University of Toronto, Dept. Electrical and Computer Engineering
mann@eecg.toronto.edu   http://wearcam.org/telepointer.htm

Abstract

Telepointer is a wearable hands-free, headwear-free device that allows the wearer to experience a visual collaborative telepresence, with text, graphics, and a shared cursor, displayed directly on real world objects. It is completely portable and can be used almost anywhere since it does not rely on infrastructure. It is operated through a Reality User Interfaces (RUI) that allows **direct** interaction with the real world, establishing a kind of computing that is completely free of metaphors.

1 If all you want to do is Augment, you don't need eyewear or headwear

Using a Reality Mediator (e.g. RM eyeglasses) to do only augmented reality (which is a special case of mediated reality) is overkill. Therefore, if all that is desired is augmented reality (e.g. if no Diminished Reality or Altered/Mediated Reality is needed), the telepointer is proposed as a Direct User Interface.

The wearable portion of the apparatus, denoted WEAR STATION in Fig 1, contains a camera, denoted WEAR CAM, which send pictures perhaps thousands of miles away, to the other portion of the apparatus, denoted BASE STATION, where the motion picture is stabilized by VideoOrbits (running on a base station computer denoted BASE COMP) and then shown by a projector, denoted PROJ., at the BASE STATION. Rays of light denoted PROJ. LIGHT reach a beamsplitter, denoted B.B.S., in the apparatus of the BASE STATION, and are partially reflected; some projected rays are considered wasted light and denoted PROJ. WASTE. Some of the light from the projector will also pass through beamsplitter B.B.S., and emerge as light rays denoted BASE LIGHT. The projected image thus appears upon a wall or other projection surface denoted as SCREEN. A person at the BASE STATION can point to projected images of any of the SUBJECT MATTER, by simply pointing a laser pointer at the SCREEN where images of the SUBJECT MATTER appear. A camera at the base station, denoted as BASE CAM provides an image of the SCREEN to the base station computer (denoted BASE COMP), by way of beamsplitter B.B.S.. The

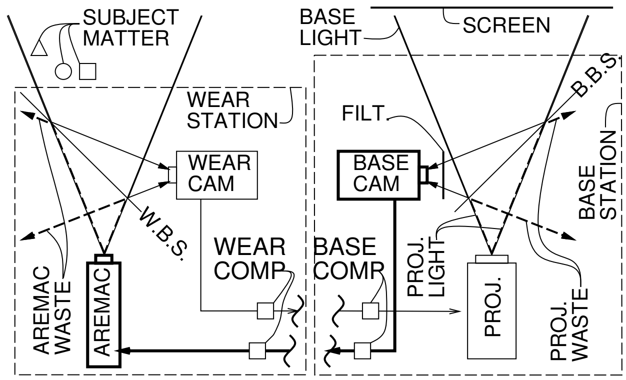

Figure 1: **telepointer system for collaborative visual telepresence without the need for eyewear or headwear or infrastructural support:** The author wears the WEAR STATION, while his wife remotely watches on a video projector, at BASE STATION. She does not need to use a mouse, keyboard, or other computerlike device to interact with the author. She simply points a laser pointer at objects displayed on the SCREEN. When he's shopping, she sees pictures of the grocery store shelves transmitted from the grocery store to the livingroom wall. She points her laser pointer at these images of objects, and this pointing action teleoperates a servo mounted laser pointer in the apparatus worn by the author. Both parties see their respective red dots in the same place. If she scribbles a circle around the milk carton, the author will see the same circle scribbled around the milk carton.

BASE CAM is usually equipped with a filter, denoted FILT., which is a narrowband bandpass filter having a passband to pass light from the laser pointer being used. Thus the BASE CAM will capture an image primarily of the laser dot on the SCREEN, and especially since a laser pointer is typically quite bright compared to a projector, the image captured by BASE CAM can be very easily made, by an appropriate exposure setting of the BASE CAM, to be black everywhere except for a small point of light from which it can be determined where the laser pointer is pointing.

The BASE CAM transmits a signal back to the WEAR COMP which controls a device called an AREMAC[1], after destabilizing the coordinates (to match the more jerky coordinate system of the WEAR CAM). SUBJECT MATTER within the field of illumination of the AREMAC scatters light from the AREMAC, so that the output of AREMAC is visible to the person wearing the WEAR STATION. A beamsplitter, denoted W.B.S., of the WEAR STATION, diverts some light from SUBJECT MATTER to the wearable camera, WEAR CAM, while allowing SUBJECT MATTER to also be illuminated by the AREMAC.

*Thanks to Xybernaut, Kodak, Digital Equipment Corporation (DEC), Compaq, Kopin, VALinux, CITO, NSERC, and Altera for assistance in this project.

[1] An aremac is to a projector as a camera is to a scanner. The aremac directs light at 3D objects.

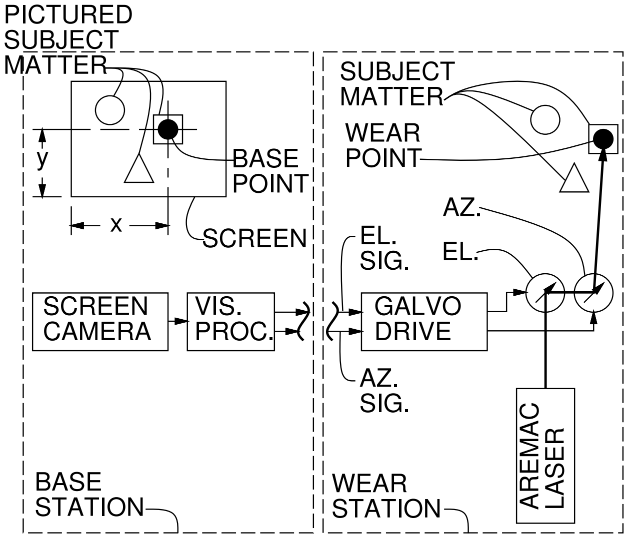

Figure 2: **Details of the telepointer (TM) aremac and its operation:** For simplicity, the livingroom or manager's office is depicted on the left, where she can point at the screen with a laser pointer. The photo studio, or grocery store, as the case may be, is depicted on the right, where a body worn laser aremac is used to direct the beam at objects in the scene.

This shared telepresence facilitates collaboration, which is especially effective when combined with the voice communications capability afforded by the use of a wearable hands–free voice communications link used together with the telepointer apparatus. (Typically the WEAR STATION provides a common data communications link having voice, video, and data communications routed through the WEAR COMP.)

Fig 2 illustrates how the telepointer works to use a laser pointer (e.g. in the livingroom) to control an aremac (wearable computer controlled laser in the grocery store). For simplicity, Fig 2 corresponds to only the portion of the signal flow path shown in bold lines of Fig 1.

SUBJECT MATTER in front of the wearer of the WEAR STATION is transmitted and displayed as PICTURED SUBJECT MATTER on the projection SCREEN. The SCREEN is updated, typically, as a live video image in a graphical browser such as glynx, while the WEAR STATION transmits live video of the SUBJECT MATTER.

One or more persons at the BASE STATION are sitting at a desk, or on a sofa, watching the large projection SCREEN, and pointing at this large projection SCREEN using a laser pointer. The laser pointer makes, upon the SCREEN, a bright red dot, designated in the figure as BASE POINT.

The BASE CAM, denoted in this figure as SCREEN CAMERA, is connected to a vision processor (denoted VIS. PROC.) of the BASE COMP, which simply determines the coordinates of the brightest point in the image seen by the SCREEN CAMERA. The SCREEN CAMERA does not need to be a high quality camera since it will only be used to see where the laser pointer is pointing. A cheap black and white camera will therefore suffice for this purpose.

Selection of the brightest pixel will tell us the coordinates, but a better estimate can be made by using the vision processor to determine the coordinates of a bright red blob, BASE POINT, to sub–pixel accuracy. This helps reduce the resolution needed, so that smaller images can be used, and therefore cheaper processing hardware and a lower resolution camera can be used for the SCREEN CAMERA.

Figure 3: **Wearable portion of apparatus, as worn by author:** The necktie mounted visual augmented reality system requires no headwear or eyewear. The apparatus is concealed in a smoked plexiglass dome of wine–dark opacity. The dark dome reduces the laser output to safe levels, while at the same time making the apparatus blatantly covert. The dome matches the decor of nearly any department store or gambling casino.

These coordinates are sent as signals denoted EL. SIG. and AZ. SIG. and are received at the WEAR STATION and are fed to a galvo drive mechanism (servo) which controls two galvos. Coordinate signal AZ. SIG. drives azimuthal galvo AZ. Coordinate signal EL. SIG. drives elevational galvo EL. These galvos are calibrated by the unit denoted as GALVO DRIVE in the figure. As a result, the AREMAC LASER is directed to form a red dot, denoted WEAR POINT, on the object that the person at the BASE STATION is pointing at from her living room or office.

The AREMAC LASER together with the GALVO DRIVE and galvos EL and AZ together comprise the device called an aremac which is generally concealed in a brooch (broche, broach) pinned onto a shirt, or exists in the form of a tie clip device for attachment to a necktie, or is built into a necklace. The author generally wears this device on a necktie. The aremac and WEAR CAM must be registered, mounted together (e.g. on the same tie clip), and properly calibrated. The aremac and WEAR CAM are typically housed in a hemispherical dome where the two are combined by way of beamsplitter W.B.S..

2 Computer Supported Collaborative Living (CSCL)

Much has been written about Computer Supported Collaborative Work (CSCW), but there is more to life than work, and more to living than pleasing one's employer. Thus the apparatus can be incorporated into ordinary day–to–day living, and used for such "tasks" as buying a house, a used car, a new sofa, or buying groceries, while a remote spouse collaborates on the purchase decision.

Fig 3 shows the author wearing the WEAR STATION in a grocery store where photography and videography are strictly prohibited.