Sewn with Ariadne's Thread – Visualizations for Wearable & Ubiquitous Computing

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Fig. 1. Author's rendition of visualizations used by or with Wearable Computers. Wearables will use various visualizations to present information to the wearer about their environment, context, activities and social interactions, as well as their emotions, health and overall well-being. These visualizations will have different levels of abstraction and granularity, whereas alternative modalities – e.g., sound — can be used in complementary fashion. (Photoshop brushes by cfowler7@http://cfowler7.deviantart.com/ and z-design@http://z-design.deviantart.com/).

Lance felt a buzz on his wrist, as *Alicia*, his wearable, informed him via the bone-conduction ear-piece - '*You have received an email from Dr Jones about the workshop*'. His wristwatch displayed an unread email glyph icon. Lance tapped it and listened to the voice of Dr Jones, talking about the latest experiment. At the same time he scanned through the email attachments, projected in front of his eyes, through his contact lenses. One of the files had a dataset of a carbon femtotube structure.

Lance tapped on the file's glyph floating in his viewpoint, feeling the touch of a button-like interface induced by the tactile mode in his wristwatch. A two-dimensional schematic of the femtotube appeared on his dinner-table's surface, with some additional annotations and a stack of related files on the side. Lance grinned happily as he 'dragged' the 2D schematic upwards and a 3D model of the femtostructure appeared on the table.

His new wearable was far more advanced than his previous one; it damn right should be as it cost him an arm and a leg to buy! But its context-awareness capabilities, seamless mode-switching and advanced AI made it worth every penny. In the distant past he only had access to the second generation wearables, which suffered from a bunch of problems. For a start, the head-mounted displays (HMDs) made people dizzy as they had to constantly switch focus between the physical and computer-generated object planes. Integration with home and office environment sensor-grids was problematic — unless one coughed-up for the almost military-grade SG-5000. Moreover, you had to be close to a touch-terminal to interact using your hands and tapping your fingers, like you were back in 2014. And most importantly, they really messed up with Lance's fashion sense, due to their ugly, bulky casings.

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But *Alicia* is the latest of a new breed of wearables that make fluid interaction a reality, and not just a marketing gimmick. First and foremost, wearables nowadays use a new generation of virtual retinal displays (VRDs, aka contact lenses) with integrated gaze and focus detection, whilst at the same time filtering irrelevant information from the sensor-grids. Secondly, true-definition pico-cameras constantly scan the physical environment with a computer-vision (CV) module, serving as primary input to the context-awareness system of the artificial intelligence (AI) core. Thermal surface-scanning complements computer-vision and detects user's interaction — touching, groping, sliding a finger — on physical objects and turns any surface into a tangible display (Fig. 2). Thirdly, and more importantly for Lance's style worries, the main wearable unit is a self-morphing, micro-fibre jacket which can simulate colours and texture of any textile surface in the world. Lance was sporting a Harris Tweed jacket today. Nothing beats the classics!

Fig. 2. Touching a surface converts the latter to a tangible display, by means of thermal detection of contact points [1]. At the same time computer-vision algorithms scan for the wearer's gestures and interactions with physical and synthetic objects.

But no wearable is complete, without its trinkets. *Alicia* can be interfaced with an array of peripherals used in Lance's work as a femtotechnology researcher, like the *Caduceus* — a wand-like device that encompasses a flexible display, with variable opacity and rigidity (Fig. 3). It can be used flat as a tablet, or 'bent' like an retro laptop. *Caduceus* also interfaces with the environment sensor-grid and, by means of electromagnetic force, can provide haptic feedback when used as a tool simulator, in Lance's hologram workbench. Usually, Lance uses the *Caduceus* as a tablet to inspect visualizations of the structural integrity data for his experimental femtotubes. Any visualization depicted in the *Caduceus* can be tossed and pinned onto objects and seen through the VRD as a three-dimensional structure broken in layers, or slices. One can interact with the 3D depictions through gestures, such as pinch to zoom, which are interpreted by the wearable's CV system.

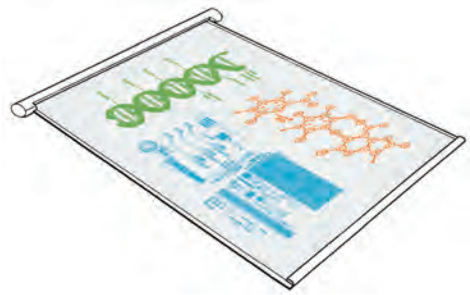

Fig. 3. For more specialized tasks a retractable, flexible-screen tablet, with variable opacity and rigidity can be used. The display, once retracted, fits into a cylinder of the size of a pen. (inspired from [2], Photoshop brushes by finner@http://finner.deviantart.com/)

In office operating conditions, *Alicia* records video and data of Lance's experiments, any comments he makes vocally and adds various data about his mental activity and emotional state. The brain-machine interface (BMI) is capable enough to assemble a list of engrams – all those subconscious thoughts that he makes during his experiments and can be used as informational filler to his more cogent observations and thoughts; a useful tool for the categorization and organization of Lance's often erratic and tangential thought-patterns.

While Lance is sleeping, the BMI continues recording his brain activity and subsequently separates and classifies his dreams. Anything work related is kept — after all he had some of his best ideas while sleeping. Any subconscious thoughts unrelated to work are discarded for privacy — and for maintaining Lance's sanity. Everything is then used to compose a life-log (Fig.4), the latest version of the Remembrance Agent [3] designed half a century ago...

Commentary

One of the most common visions that people describe when they talk about the future of human-computer interaction is that of a world akin to that described by Vernon Vinge in Rainbows End [4], where data is embedded in various different ways in our surrounding environment. Our short view-in-the-future follows the same style; paradigms like ubiquitous computing [5], wearable computing [3] and mixed/augmented reality [6, 7] often portray, from different perspectives, a hybrid, context-aware space where digital information enhances the informational content of our physical surroundings.

Realizing this vision, poses a number of challenges, mainly because these paradigms attempt to be more immediate to our human nature, compared to Desktop/WIMP interfaces. For instance, HMDs sometimes make people dizzy and disorientated compared to a desktop screens. Carrying around a wearable can be a burden, both in terms of ergonomics as well as social acceptance. Computers holding personal information and placed ubiquitously in our world have privacy and security implications. Yet we want to overcome those challenges and alter the way we interact with technology - which in many ways has not changed since personal computers appeared. We seek to interact with technology more naturally, with greater fluidity [8]. We want to intertwine it with our lives [9]. We want to use all our senses to offer a better user experience [10] and make technology more aware of our human nature [11].

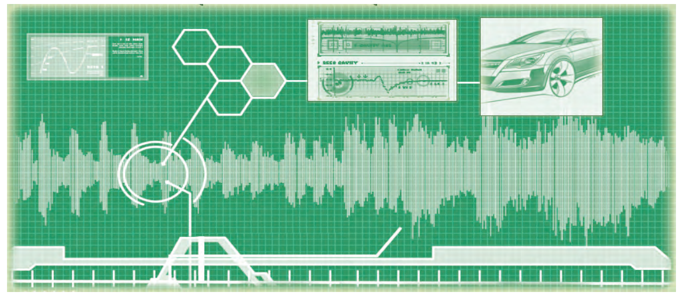

Fig. 4. Example of a life-log timeline visualization, depicting videos of daily activities and BMI-data, cross-referenced to events. The wearer can use this as a real-time micro-logging tool and revisit daily events.

The first steps towards this synthetic-world have already been taken with the advent of HMDs, force-feedback joysticks, haptic and tangible interfaces. Researchers have been using such devices to fabricate prototypes for a couple of decades. But, nowadays, the interest to get prototypes out of the lab and to consumers is higher than ever. Some prototypes gradually find their way into our homes and everyday lives, in the form of entertainment and gaming interfaces (e.g., Oculus Rift). Others, such as Google's Glass generate unprecedented interest — to the point of being over-hyped in some cases — and promises of new interactive service paradigms.

We are therefore facing challenges and opportunities, as we gradually step away from our desktop computers and we use mobile and wearable visualization systems [12] and devices. Challenges such as finding new ways to visualize and interact in real-time with information displayed in smaller, hand-held, wearable or 'virtual screens. Opportunities such as exploring new ways to visualize information, or better still, perceive it using all our senses [9]. The next couple of decades will be exciting, as far as visualization and HCI are concerned.

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