Wearing the Playware

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Abstract

In this conceptual paper, we describe and define the range of possible applications and the technical contours of a robotic system to be worn on the body for playful interactions. Earlier work on Modular Robotic Wearable, MRW, described how, by using modular robotics for creating wearable, it is possible to obtain a flexible wearable processing system, where freely inter-changeable input/output modules can be positioned on the body suit in accordance with the task at hand. Here, we drive the attention on early prototypes to show the potentialities of such an approach, and focus on depicting possible application in the electronic games domain. Indeed, the Modular Robotic Wearable is an example of modular playware, which can create playful interactions for many application domains, including electronic games.

Modular Robotic Wearable and Gaming

The Modular Robotic Wearable (MRW) technology [1] is an attempt to build a ubiquitous gaming interface strictly keeping in mind the early future of computer game design and game play. It considers the research and development of tangible narratives and live role-playing games, as well as interactive narrative experiences moving away from traditional media to fully embrace the physical surrounding. The MRW technology is designed for ubiquity, sensitivity, and tangibility, and it enhances electronic devices interfaces to bring them in a real-world/real-body context through the use of multiple sensors detecting posture, gesture, physical and body parameters, location, proximity, direction, etc.

The basic idea underlying the MRW systems is to move the games interaction out of the usual "push the button", "click here" or the "move the stick" routine, to reach a body-game interrelation experience which should be in part conscious and, in part, unconscious or automated. Therefore, the challenge is to design a general gaming interface that focuses on the player's body interaction with real world, and possibly a social environment. Indeed, we believe that the player can be easily identified as a specific and unique character/personality which can be measured, quantified, and formalized, through body actions and interactions, in order to play his/her specific/personalized role. (An example of categorization of players on playgrounds is provided in [2].)

Through the use of the MRW technology, a large set of games can be conceived as a body-to-body set-up, hence without any intervening external hardware or software. That is because once certain MRW modules are worn, they transform the user into a "physical agent" in the world as well as between other physical agents. Therefore, we can hypothesize any behavior based (e.g. flocking) or ambient related (i.e. physical parameter chasing) game.

Physical game interfaces

For decades, the arcade game industry has developed physical game interfaces. In the 1990's, Konami developed the BEMANI (BeatMania) series of music games (e.g. Physical DJ games) and Namco developed the famous Taiko no Tatsujin drum game, where the player has to physically hit the drum with two large drumsticks based upon the colored circles that appear on the graphical monitor encoded to follow the drum beat. This physical game structure was developed in a very similar form into numerous physical music interaction games such as GuitarFreaks, Guitar Hero, Drumania, Dance Dance Revolution, etc. Also, the arcade game industry developed physical game interfaces for shooter games (e.g. guns) and sports games (e.g. skies, sports cars). Such arcade game machines are typically expensive, with the cost in the order of 10.000 USD, but over the last decade, cheaper versions have penetrated into the consumer game market. Sony developed the Eye-toys with a camera detecting physical motions for creating a home use physical interaction to games, and also early examples include simple guns for shooter games and simple steering wheels for racing car games. Simple dancing mats were developed for Disney games and dancing games, and later electronic plastic guitars were made for Guitar Hero and similar music games duplicating the arcade games.

It is clear that Nintendo revolutionized the game console market with the launch of the Nintendo Wii, which has sold a volume of approximately 70 million. Wii's hand-held game controller embeds a 3-axis accelerometer and IR sensor to measure motion, using an infra-red light reference to calibrate the motion relative to a fixed source. With the Nintendo Wii, physical game interaction has positioned itself as a very important part of a large part of gaming.

In parallel to this development for home use of physical game interfaces, there has been a development of physical game interfaces for fitness and health, also known as exergames (exercise games). Numerous exergames are developed. The different kinds of sensory exercise bikes with interface to screen based games is a simple example (e.g. [3]), and numerous other physical exercise interfaces were developed for screen based games, e.g. Trazer and Dance Dance Revolution for health and fitness purposes. Also, Wii Fit was developed as a physical exergame interface to screen based games. However, many exergames are also developed to be stand alone physical games without graphical game interfaces on a screen, in order to facilitate the set-up and versatility of use. These physical exergame products include LightSpace, tWall, skywall, DigiWall, sportstrainer, Makoto, etc. In these cases, the set-up is fixed for the user. In contrast, as an exergame, Modular Robotic Tiles provide the opportunity to have a flexible set-up which can easily be set up by any user within a minute [4, 5].

Another category of physical game interfaces are technology enhanced playgrounds such as the Smart-Us from Lappset, and the ICON from KOMPAN. In these cases, playgrounds are enhanced with sensors, typically touch sensors, and the playgrounds will react dependent on the children's physical movements on the playground. Smart-Us is mainly screen based, so that the feedback on the physical interaction happens graphically on a screen, whereas ICON avoids the screen and provides sound and colored light feedback from items placed on the traditional playground equipment itself.

Also, physical user interfaces have been developed for mobile games. For instance Bleecker and Brinson [6] used a tablet PC and 3–axis orientation sensor to allow the players to observe the entire game scene by physically moving their bodies in a full 360 degree circle. Other handheld consoles with tilt sensors such as i-Phone and Nintendo Game Boy Advance are used for physical interactions to control screen based games (on the small handheld console screen). Further, augmented reality games, such as augmenting traditional toys with RFID tags (e.g. by Miglino et al. and numerous products on the market), may allow the toy object to react dependent on where the player physically move it (on top of RFID tag readers).

Other mobile games with physical body interaction include location based games, both on a small scale indoor with tracking systems using IR, cameras, etc., and on a larger scale outdoor using GPS and mobile phone signals. Outdoor location based games often demand the players to move around physically, e.g. in the city space, while having mobile phones or other handheld devices with small screens tracked through GPS signals. An example of a contextualized location based game, Visions of Sara, is developed by Ejsing-Duun and DJEEO [7]. The indoor systems are often bulky and demand the set-up of an infrastructure, careful calibration, etc. For instance, this is often the case when using camera-projector systems (e.g. [8]), though the camera-projector systems can provide for interesting physical interaction and displays such as the systems from Snibbe Interactive (e.g. exhibited at MoMa). A number of projects have made set-ups to track 3D gestures, and for instance Payne et. al. [9] tested how 3D gestures affect usability and "fun" for screen based game user interfaces.

The physical game interfaces may also provide social interaction over distance, where users interact physically at one location to manipulate signals (the game) at another location. For instance, Mueller et al. showed how physical ball game activities were transferred over distance to a user at another location as overlayed video conferencing [10]. Such haptic interfaces for social interaction over distance can take many forms. For instance, in 2001, the New York Hall of Science arranged a tug-of-war between two teams of children 13 miles apart from each.

When designing for a playful human physical interaction, it is of course important to consider what category of physical interaction is intended. For instance, some physical game interfaces may not withstand strong physical actions, whereas others may be designed for forceful, strong interactions with the body, such as required in many sports activities [11]. As a guideline for the design of interactive device(s), it is important to design the interactive device(s) with the physical activity and use in mind.

MRW Definition and Characteristics

Modular Robotic Wearable (MRW) was defined [1] as a robotic system composed of interactive robotic modules which are worn on the body.

- By wearable we intend that the system has to be worn on the body and interact with the body as part of the surrounding environment of the system.
- By a robotic module we intend an entity with a physical expression which is able to process and communicate with its surroundings. The communication can be directed towards neighbouring modules and/or via sensory input and actuation output to the surroundings (i.e. interactive robotic modules). A modular robotic system is constructed from many such robotic modules.

Modular Robotic Wearable combines the wearable with the modular robotics and exploits the intersection of this combination. This, in combination with the design guidelines for modular playware [12], provides an opportunity to obtain a flexible wearable processing system, where input/output modules (robotic modules) are freely interchangeable and freely can be positioned on the body suit in accordance with the task at hand. As with any modular robotic system, the design of the individual module is crucial for the performance of the modular robotic wearable. Design issues include attachment mechanism, communication method, size, form, material, and energy as well as the definition of processing, input and output capabilities. An example of MRW is presented with the Fatherboard (Fig. 1) [1, 13].

MRW advantages can be summarized as:

- lightweight, small physical device size;
- lightweight operating system which demands fewer resources;
- good battery life;
- near instant on/off;
- modular, both in configuration and run time use;
- distributed, so components can be worn all over the body for greater comfort;
- customizable;
- cable free, where possible

MRW aims to be a set of networked intelligent modules for the body-state, motion and feeling capture, in virtual and real realities. For example the enhancement powered by affect sensitive action/feeling can be easily applied to software like chats, e-games, iPhone, and etc. in order to reinforce and intensify own feelings, and reproduce and simulate the emotions felt by the partner (either virtual or real) during wired or wireless communication. Such an implemented system can considerably enhance emotionally immersive experience providing feelings of co-presence and intensifies our emotions through the senses. This is both for basic and complex emotion.

We are now experimenting with textile bands, and considering the use of different tools which might be applied to special body parts like fingers, eyes, etc. (see [1,13] for details). This is because we believe that e.g. a field like personalized long-term healthcare monitoring will become fundamental to improve medicine's capabilities for diagnosing and correctly treating diseases at an early stage, therefore the production of wearable wireless sensor networks for health monitoring such as those provided by the MRW system might be essential.

Indeed, a crucial role might be played by textile-based electronic sensors, especially if for monitoring and measuring healthcare parameters. These include ECG active electrodes; capacitance sensors for respiration monitoring; modular wireless sensor node system into several health monitoring clothing applications.

Figure 1. The Fatherboard – one of our first examples of a Modular Robotic Wearable (MRW), see [1, 13].

Interfacing MRW to games and play

Studying MRW may provide a fundamental understanding of how humans and autonomous machine agents can operate efficiently as teams to accomplish mission objectives and share in tasks in a way that the differing abilities of the humans and machines are used to best advantage. This sharing and interactions can happen with immersive 3D VR techniques, games, etc. on one side, and reactive physical material on the other side, e.g. augmented reality object (RFID) and special robots / automated machines that perform complex tasks with certain impact. In both cases, we can study the interaction as a play scenario.

For such studies, we can utilise one of the major advantages of MRW systems, namely the possibility to interface it with existing commercial devices like games and other products. When doing so, we must consider that a MWR device is both multifaceted and multi-modal, since it might serve a software with almost any kind of information coming from almost any part of the body. Being multi-connected to electronic artefacts means, besides controlling a large part of the physical-to-virtual representation of the body, to speed the dialog with any software and to, eventually, open to unconscious reactions. Thus enhancing the interfacing to a much higher level of human-machine interrelation and pushing the game to a much higher emotional level.

Once certain MRW modules are worn, they transform the user into a "physical agent" in the world, as well as a physical agent between other physical agents. Therefore, with MRW we can hypothesize any behavior based (e.g. flocking) or ambient related (i.e. physical parameter chasing) game.

MRW modules are realized in such a way that they can interact via wireless connection with both a specific hardware (e.g., Bluetooth, XBee) or amongst each other (e.g. Xbee). In this way, modules positioned on strategical places of the body, say the hands, the feet, the heart, and so on can communicate their *acceleration*, *3D position* and *state* to virtual/real companion/adversary both in software and real games extending the physical capabilities of the players. One interesting point of such a tool is that the modules, being in most cases plug-and-play and easily applicable can be replaced and substituted quickly or, vice-versa, can be switched from one player's costume to another player's costume, right away. This may increase the game(s) dynamic and favor the exchange of roles amongst players. In this sense, such modules can provide the player with an immediate feedback (e.g. through lights, vibrations and sounds) enhancing the personal experience to a personal and 'believable' level.

Further, since some modules are built in order to perceive and measure ambient circumstances and parameters (i.e. proximity, distance, temperature, humidity, light, etc.) they enlarge considerably the feeling of the player of being immerse into the world, and the idea of using the physical world as part of the game. Hence, such modules might result very significant when trying to conceive immersion and engagement in games and tend to arise the feeling of location-dependent actions/reaction. Being lightweight and wearable, MRW based games might easily be played everywhere – especially when not incorporating external devices.

Finally, some of the modules, e.g. for the Fatherboard (see Fig. 1 and [1, 13] for details), were conceived for aesthetic purposes (i.e. lights, sounds, etc.) and were thought as for being activated either by the *host agent* (i.e. the player wearing the specific module) and the *client agent* (i.e. the other player/s). Such a conception, besides increasing the elegance of the game and the aesthetic of interaction power of "seduction" of the games, sometimes raise them to a "magic" level -- it is the "magic" makes the difference when differentiating games and beautiful games. Despite of that, of course, such aesthetics-modules besides being for the "fantasy" might still be realistic and functional with the MRW approach.

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