Soft Computation in the Public Sphere: Enhancing Social Dynamics with Wearable Networks

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Abstract. The use of clothing as a vehicle for communication is as old as the garment itself. Over the last few centuries the signaling function of dress has declined into the symbolic and anonymous. Increasing privatization of society, has led to nearly half of its population suffering from debilitating loneliness. Positioned within Positive Computing, this paper examines the possibilities of non screen-based digital personal artifacts, in the form of Soft User Interfaces, to enhance social dynamics. This paper provides a case study on the use of non-verbal signaling as the foundation for soft computation deployed in the public sphere. The proposed technology is aimed at strengthening social capital, by freeing up situated user attention and facilitate the formation of wearable networks upon establishment of mutual sympathy during chance encounters in public space.

Keywords: Photonic displays · Smart fashion · Embedded electronics · Wearable networks · Interactive technology · Soft user interface · Physical computing · Soft computation · Social dynamics · Public sphere · Positive computing · Non-verbal signaling · Proximity · Artifactics

1 Introduction

Clothing has been described as the first public display, both in terms of the individual, but also in the history of humanity as a whole. Whilst theories diverge, recent studies imply that clothing developed from adornments as a medium of communication, most likely for ritual or prestigious purposes [1, 2].

The communication and signaling that emerge from personal objects, such as dress or fashion accessories, is described as artifactics and plays an important part of dress even today. The choice of garment is not just a way of communicating who someone is as a person and which station he or she holds, but is also a tool which can be directly manipulated, as to how a member of society wishes to establish their identity. Clothing acts as an extension and expression of the self and communicates a wide array of meanings, encompassing not just identity, gender and political and social standing but also temporary mood and attitude, as well as the moral and aesthetic standards of both the individual and society [3, 4].

Over the last centuries the way clothes have been used in public has undergone extreme changes. Up until the seventeenth century, garments were used to mark the

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place a member held in society and consisted of a system of clearly understandable and discernible signs. With the advent of mechanization, clothing became standardized and people became indistinguishable from each other. The signaling became very symbolic, that is the reading and deciphering of the signals sent by the clothes, were only readable by the initiated, who was able to discern amongst the subtly send cues [5]. Concurrently societal structures shifted from predominantly public and clearly demarcated, to increasingly private and anonymous, a development that has had an immensely detrimental effect on the public sphere [6]. At present increasing urban loneliness is becoming a major public health concern, with the amount of sufferers predicted to increase to fifty percent by 2028 [7]. Loneliness is one of the paradoxical hallmarks of contemporary existence. Never in history has humanity been as connected and as adrift, as today. Modern technology, in this respect, seems to be both curse and cure. Individualized media technology on one hand lets everyone retreat into their individualized bubble and private space seems to completely displace the public, with everyone immersed into the screen of a mobile device, yet the same technology has time and again proved itself invaluable in bringing about civic engagement and involvement. The potential of Information and Communication Technology (ICT) and the Internet Of Things (IoT) to address complex issues and foster civic engagement, has been demonstrated by numerous smart applications developed in recent years. Among the first and most prominent is the often cited app *Citizen Connect* developed by MIT's Media Lab for the city of Boston. The app basically allows users to report issues online to local authorities, who will then alert whichever team responsible for attending to the problem at hand. The app vastly super-ceded the developers initial expectations, as the workers assigned to tend to the city's maintenance, simply started watching the online feed and respond immediately, without waiting for instructions from the central authorities [8]. This is just one case illustrating how the infrastructure these technologies provide allows the individual access to peer-to-peer resources almost instantaneously and at a scale previously impossible to mobilize [9].

2 Research Focus

It is the focus of this paper to examine the potential of soft computational technology to improve social dynamics, by extending the inherent signaling abilities of clothing, from passive one-to-many type broadcasting of wearer identity to an interactive technology, which engages its wearers into a relationship of exchange with each other and the environment, without the sensory and cognitive overload and lack of attention and situated awareness, which often accompanies screen-based devices [10]. Besides some technical challenges remaining to be resolved, such as cumbersome batteries and maintenance, one of the biggest challenges facing the development and adoption of computational clothing into existing channels of communication and use in public space, is the amount of functionality to include in the textile and how to properly approach the integration of information flow. Users today are already overwhelmed by the ever-increasing amount of data supplied by their mobile devices, which are detachable from the body. Adding a constantly pinging and buzzing garment, which cannot easily be removed, can quickly

be perceived as more of a nuisance that an asset to the wearer. Therefore the proposed technology strives to limit attention requiring user-garment interaction, yet still ascertain the wearer an option of control to ensure instant opt-out at any given time.

Secondly, most users have no interest in complicating basic daily occurrences such as dressing. Hence the focus is on pre-attentive data and single pixel type displays, subtly integrated into the fashionable expression of a garment with reduced functionality, gently extending existing technologies to ensure user acceptance. As the focus of application is within public space and previous research has shown users to be generally apprehensive towards publicly using exposing technology, any sort of display of biodata has been omitted.

3 Applied Methods

The presented case study *enLight* is part of a bigger research project on the potential of digitally enhanced clothing, as a means to enable communication in the public sphere. Photonic materials, near proximity awareness and non-verbal communication cues, as basis of operating mechanisms applied to extend existing channels of human communication, has previously been explored in the *Lightning Bug*, a case study resulting in the development of Soft User Interfaces (SUI). These previous findings constitute the foundation of the research presented in this paper [11, 12].

Coming from a creative and studio-based background, this and previous research was conducted in a very hands-on fashion, where initial hypothesis is stated in the form of a prototype design. Based on the emerging findings, the design is then successively improved upon [13]. The first prototype in this series utilized luminous fibre integrated in knitwear for signaling. Iterating on this design, a fabric based computational interface, in the form of a jacket with a prefabricated photonic inlay, was developed. The interface was designed to adhere to the principles of a SUI, i.e. it has no screens or other way of using text or image-based communicative tools, it's operation relies on biometric and contextually relevant data, in conjunction with nonverbal communication cues, it has a flexible substrate and is as easy to wear as a conventional garment and does not require any additional training or configuration [14]. For prototyping and testing purposes, a total of five jackets were fashioned in a unisex design and a preliminary study was conducted including both students and older users from mixed occupational backgrounds.

4 The enLight System

The jacket is the wearable part of a mixed platform device, working in conjunction with a mobile app. Configured with the user's preferences, the jacket is able to facilitate interaction between wearers, upon detection of a certain compatibility. Controlling the jacket requires no direct action of the wearer, as it utilizes data from integrated sound and proximity sensors, to analyze it's wearers nonverbal cues and subsequently takes action based there-on. Visual feedback to operations taking place as well as notifications are iconically expressed using the jackets luminous fabric as a single pixel display,

supported by a small vibration motor adding tactile stimuli. A zipper switch is integrated into the design, serving as a "kill switch" in order to ensure full user control of the wearable at any given time.

4.1 The enLight App

Before first usage the system is configured with the wearers preferences and interests via a mobile app, which was designed for minimum interaction. Users can enter their name and email and state their interests and skill-sets, picking from three dropdown menus. Additional interests can be added to the system and a picture upload is optional. This establishes an online profile and filters all subsequent interaction facilitated by the system. As the user establishes contacts, the app can then further be used to message, endorse and search among contacts (Fig. 1).

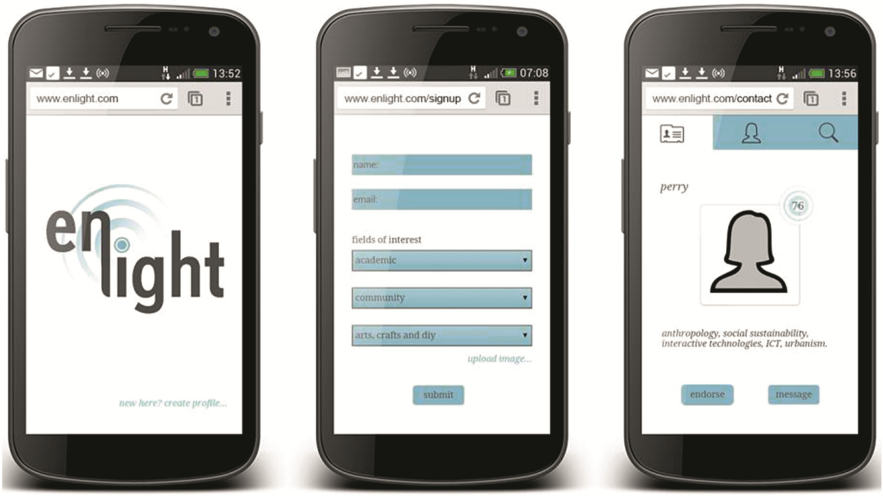

Fig. 1. *enLight* app prototype (Illustration Frankjær)

4.2 The enLight Wearable

The *enLight* jackets are fashioned from neoprene, with an inlay of polychrome fiberoptic fabric, which effectively renders the wearable a single pixel display. The jackets operate in six different modes (Fig. 2):

4.2.1 Listening Mode

In listening mode the garment scans the surrounding environment for *enLight* wearables in proximity. Depending on conditions (inside/outside/crowded/build-up) the radius of

the scan is about one hundred meters. This space correlates with the perceptual abilities of the human senses[1].

The jacket and the fabric display is dormant and will show the base color of the fibre-optical fabric. In the background the returned data from the area scan is analyzed to find SUIs with corresponding preferences.

4.2.2 Active Mode

Upon detection of a SUI with corresponding preferences the fibre-optic panel starts slowly emitting pulsing light in the color of the fabric inlay. The rhythm of the pulse gives the impression of breathing, i.e., the jacket is visually "coming to life". In addition to the pulsing light of the luminous fibers, a short vibration directs the wearers attention to the jacket and supports the photonic signal in brightly lit situations.

4.2.3 Interactive Mode

Informed by the activation of the SUI, the attention of the wearer can now be directed towards the surrounding physical space to detect the trigger. The speed of the pulse will increase correspondingly to decreasing distance between two interacting SUIs. When entering social space, i.e., talking distance at about two meters distance the SUIs engage and take on each others color in a loop, which can include an indefinite amount of collocated SUIs [15].

4.2.4 Connected Mode

Upon disengagement of the collocated SUIs the system will calculate if the wearers of the system spend any noteworthy amount of time in each others social space and whether conversation took place during that time-period. These two datasets provide the basis for the system to assess whether sympathy ensued out of the encounter. If so, wearers will be added to each others contact lists and their data can be accessed for skills and name based search, messaging and endorsement.

4.2.5 Panic Mode

Panic mode can be triggered by a slight manipulation of the zipper head on the front of the jacket during the SUI's active states, i.e., 4.2.4–4.2.5 and will result in the system aborting all operations and shutting down. To start the system up again the zipper must be returned to its original position.

4.3 Technical Details

Each *enLight* jacket is powered by a 5 Volt rechargeable power supply and fitted with a Spark Core micro-controller driven by an ARM Cortex M3 and Texas Instruments SimpleLink CC3000 Wi-Fi chip (Fig. 3).

[1] Humans are incapable of scanning an area greater than 100 m, which explains the uneasy feelings generally caused by vast open spaces. As this emotion is caused by a physiological trait, it is true independently of cultural preferences [16].

Fig. 2. *enLight* jackets in various states of display (Photo: Frankjaer)

The RSSI of an Xbee radio module is used to establish proximity and orientation, whilst a MEMS microphone detects oratory signal. A vibration motor supports the visual signal from the Lumitex fabric, which has had it's monochrome LED replaced with an RGB LED to fashion a material capable of color-change.

4.4 User Interaction

The *enLight* system is designed in such a way that the user does not have to become active for it to work, but simply uses it as a conventional garment. By gathering simple sensor values, proximity, orientation, timeframe of collocation and use of voice can be

Fig. 3. The *enLight* jacket with components (Illustration: Frankjaer)

established. These make up a large part of the users non-verbal signals, which the system analyzes to gauge user intentions, on which it then bases its operations. The only exception to this is the zipper switch, which allows the user to manually override the system.

5 Related Work

The idea of automating relationships between interactants using digital agents dates back at least thirty years with early visionary works, such as *Liveware,* which lacked the wireless infrastructure, required its members to physically carry and exchange floppy disks during encounters [17]. The research of the Wearable Computing Group at the University of Oregon at the turn of the century, aimed to develop wearable and mobile computing technology for facilitating and augmenting trust-based human collaboration and has been very influential on the development of the *enLight,* as has Howard Rhinegold's notion of seeking ways to 'reunite social space and physical place' and Ariana de Souza e Silva's work on Hybrid Space [18–20]. More recently a great deal of applications have been developed within ICT, utilizing locative systems to enable and encourage direct citizen engagement, as in the mentioned *Citizen Connect* in Boston. Other initiatives include *Adopt a Hydrant,* a gamified web application, where citizens take responsibility for keeping a particular fire hydrant free of snow in the winter-months, whereby any hydrant that is

spotted uncleared can be claimed by others using an online map [21]. A similar initiative has been implemented in Honolulu addressing maintenance of tsunami-sirens [22]. In Aarhus the *City Bug Report* functions similarly to *Citizens Connect* but with an added public display on the city's city hall tower [23].

Recently the term *Positive Computing* has emerged, defined as 'the design and development of technology to support wellbeing and human potential' [24]. This project can be assigned to this category.

In the field of Smart Fashion a few wearable devices and garments have been proposed, which in some way or other, address social networking, often in the form of bracelets signaling when a like-minded person would be in proximity. One project suggests scanning Facebook for common interests and subsequently send friend requests [25]. The Ping Dress by Electric Foxy, can receive Facebook notifications and the Twitter Dress by Cute Circuit displays the wearers feed [26, 27]. Another project by Cute Circuit is the Hug Shirt, which through the use of actuators allows users to send each other hugs [28]. Although not having reached any kind of commercial significance, these kind of projects do indicate a growing awareness of the possibilities of Smart Fashion deployed in social space.

In the mobile market there is a plethora of apps based on GPS, to find nearby people, mainly for dating purposes such as Tinder, Blendr and Badoo but also more serious apps like Smacktive, helping users to find nearby partners for platonic activities [29–32].

6 Discussion/Results

It is estimated that 70–90 percent of inter-human communication takes place using non-verbal cues, yet screen based devices rely exclusively on text and voice input, which effectively means a loss of the majority human expression [33]. The focus required to interact in this manner demands complete attention and so people tend to "disappear" into the screens of their mobile devices. Private space thus effectively invades and displaces the public [34].

Largely removing the screen by integrating simple sensing technology into clothing, and analyzing users' non-verbal cues, such as phonetics, proxemics and chronemics, opens up new possibilities of developing algorithms that can act upon users emotional propensities, without them having to direct their attention to the system.

In the study the *enLight* was met with a considerable amount of skepticism from users, who either doubted its accuracy or felt uncomfortable with an automated agent basing its actions on what might be perceived as unconscious and not really wanted on their part. Here the challenge of the designer lies in designing the system in such a way to ensure the user feels safe and in control at all times. Demonstrating the function of the zipper-switch and clarifying that the system is based on active physical signaling, which will naturally not occur if a situation is not desired, to a large extend alleviated the doubts. Having moved beyond these initial difficulties, user reaction was generally very positive towards the factually non-existent interaction with the garment, however the "creepiness" which accompanies any sort of automation remains an area which has to be firmly addressed to ensure user acceptance of such products on a larger scale.

The aim of the *enLight* is to enhance the public sphere, by augmenting the distinct skill-base and interests of the user and present them to the world in such a way that interaction with others is only initiated in case of similarities, i.e., it is likely that mutual benefit will arise from the relation,

As with any filter function this may have the negative effect of increasing the social 'bubbling', where the only others who are allowed in are like-minded, that do not disrupt personal comfort zones.

Yet in order for the public sphere to function it is important that the exchange that happens is within a heterogeneous population, bringing people from different backgrounds together. Here the *enLight* can provide a safe space, since no data will be exchanged if interactants have not developed mutual sympathy. In conjunction with strong user control at any given time, these parameters of interaction open up new possibilities for strangers to engage with each other in an anonymous environment, without the danger of unpleasantly encroaching on or breaching each others personal space, or feeling pressured to make unwanted commitments.

It could be argued, that by introducing an app interface into the system, the enLight is not a SUI in that the garment itself may be devoid of any screens, yet screens are still present within the system. However, as it is the intention of the project to free up situated user attention, by delegating those functionalities to the periphery, which do not necessarily require direct interaction or user engagement, the enLight exploits the strengths of each medium. For conducting tasks such as the original configuring of the garment and later search, messaging and endorsements, the screen interface has proved superior as these activities denote reflective cognitive processes. Navigating the app proved without any difficulty. The low entry-level barrier and restricted functionality lets the user switch effortlessly between the two platforms and ensures an aesthetic interaction experience across the different platforms.

7 Future Development

Following a bigger study into user acceptance and integration into daily life, the next iteration of the *enLight* will aim to improve the sympathy algorithm by deploying more sensors and a more complex algorithm. Immediate plans are to analyze the voice input to establish emotion in the pitch, as well as accelerometers to gauge posture, in order to integrate kinesics into the system, which are very effective in establishing a wearers attitude towards an occurring situation [35]. Expanding on the design of the SUI itself, integrating the *enLight* technology in various kinds of garments are planned and the project will be published under a Creative Commons license, encouraging anyone to develop their own *enLight* capable device to suit their taste and needs.

Further iterations will expand on the capabilities of the garments to integrate location-based services. For instance reminding users to shop for a certain item when in the vicinity of the appropriate shop and developed to incorporate the community, by the agent asking if a user could acquire a certain item needed by a contact, who happens to be on that users route. In this way contacts are of increased benefit to each other, without exerting much additional effort. In addition to increasing points of interaction and non-monetary

exchanges, new habits of acting outside the purely personal realm are shaped, leading to an enhanced social dynamics and thereby increases social capital.

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