Specch.io: A Personal QS Mirror for Life Patterns Discovery and "Self" Reshaping

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Abstract. This paper describes the process that led to the design of the *Specch.io* framework. *Specch.io* is a platform for seamless data collection, mash-up, visualization and exploration of personal data. The project is part of an internal research track focused on the usage of technology to promote and foster individual well-being from a biopsychosocial (BPS) perspective. The objective of *Specch.io,* is to reveal and raise awareness on individual life patterns, generating integration and meaning about aspects of the "self" that can hardly be captured from a subjective point of view.

Keywords: Quantified Self, Personal Informatics, Self-Ethnography, Self-Experimentation, Life-logging, Ubiquitous Computing, Human-Computer Interaction, Info visualization.

1 Introduction

As a research group at a leading Telco, we began to work on this project having observed and developed the awareness that being "hyper-connected" and "always on" does not generally make peoples' lives better in terms of quality of life. The aim was therefore to think of a new way of being always connected: a "service" vision of the future Internet in which the labels "being wired" and "smart life" will mean to return to and recover the real and tangible dimension of existence, however assisted by highly valuable but invisible technological aspects; in other words, a phenomenon of technological re-humanization similar to that seen in other sectors, such as in mobility and urban planning towards a vision of a smart city, or nutrition and energy towards a vision of sustainable consumption.

To undertake this direction, we focused on recent research within the fields of the quantified self (QS) and personal informatics (PI). These strands contain the initial elements of a different meaning, a new interpretation on the technological aspect of being "always on", putting into foreground peoples' awareness of their patterns and specificities, thereby giving "hyper connectivity" a positive role. The purpose of collecting personal information in different areas of people's lives (i.e. location, mood, food, fitness, money, digital usage, health, etc.) has become in these approaches a means to improve knowledge about patterns of action, consequently improving

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self-awareness and promoting change towards a higher level of personal well-being, albeit typically limited to only a few discrete aspects.

Our project embraced this approach by integrating it with a broader theoretical and technological perspective that not only included a concept of physical well-being, but also (and mostly) took into account psychological and social well-being. On the other hand, it also promoted different forms of possible "change". In actual fact, most of the literature in the areas mentioned above (QS and PI) merely address potential behavioral change oriented to correcting basic parameters (e.g. weight, calories, activity, etc.). We believe change can take many forms (i.e. cognitive reshaping), and can have different levels of depth both in terms of its impact on the structure of the person, as well as on duration (behavioral changes usually have an impact on a superficial level and do not last for a long time). Our project has been to build a platform that allows access to an integrated view of the person, and is directed at improving knowledge of one's own life patterns, increasing one's overall awareness through the emergence of significant causal or space-time correlations, and hence facilitating change (whether environmental, behavioral, or cognitive) towards a higher level of personal biopsychosocial well-being. In this work, we intend to describe the basis on which we began to build what we think might be a transparent and integrated system as a generator of new meanings for the end user. We started from the literature and various experiments made in the last twenty years, and considered the relevant literature about change that surpass the behavioral standpoint. This analysis and our own personal backgrounds has led to the choice of a theoretical framework based on a constructivist and post-rationalist perspective [19] that in our opinion overcomes the shortcomings of behaviorism and cognitive rationalism. Moreover, we involved a panel of people involved in self-logging practices in order to gather requirements from which to start to develop our system. On the basis of this knowledge, we have developed a concept and a prototype in our laboratories that give shape to our idea, and these allow us to further investigate all the technological and human aspects involved. Thus was born Specch.io.

2 Related Works and Theoretical Framework

We analyzed the pertinent literature of different scientific fields (Computer Science, Psychology, Sociology, Anthropology) for some macro themes concerning our work. At first we adopted an historical perspective examining some well-known lifelogging projects [14] identifying value aspects and obstacles within them. We considered some pioneering work of which we cite as examples MyLifeBits [4] [16], Total Recall and the LifeLog Project as well the limitations that characterized them. In addition to the obvious constraints in terms of technological availability [21],[31], storage [13], data collection and information management [1],what interested us most was the emergence of non-technological aspects fundamentally related with ethical [25] and privacy [2] issues. We then reviewed some Personal Informatics works in light of Li's [24][23] definition, examining emerging opportunities and new limitations in comparison to the first lifelogging projects. Consistent with our vision, it is clear from these

works that an inherent aim is the notion of change. However, this is primarily related to behavioral economics models or, as in the case of Li [23] or He [20] to a specific model of behavioral change like the transtheoretical model of change (TTM) [34]. A topic of specific interest for our project was the analysis of issues related to the ease of personal data collection [36] and the possibilities of integration between different data sources. Both are partly advocated by the relevant literature [23] and partly developed in different projects [29] and different trials [5], although never fully accomplished and always a source of difficulty [47]. We then focused on the contact stage between the system and the user: the interface that provides visual access to personal data, which should foster sense-making for the person. In this sense, we have examined the fundamental works of Tukey [45] Tufte [44] and Card [7] in addition to the complete works of Ware [46] and Few [15]. We then focused on studies of big screens starting our review from ambitious [6],[38] and futuristic [11] projects to the latest applications [30] in this field. Furthermore the specific functional or perceptive limits of some solutions [42] have allowed us to choose an appropriate hardware configuration for our project. Last but not least we carried out an extensive analysis on the human change issue and the limitations of purely behavioral change [9],[10],[12],[35]. As we mentioned above our motivation to start this project did not draw on the themes of persuasive technology intended to change patterns of dysfunctional behavior, but rather on a vision aimed at creating a "tool" for enabling higher levels of integration and well-being [26] in the sense of Siegel [39]. We therefore considered that the current outlook was too limiting for us and out of our scope. We therefore retraced the last decades of cognitive psychology from Skinner [41] and Miller [27] passing through the Lewin's fundamental advances on the role of the context [22] to Bandura's more recent models on cognitive-emotional processes [3]. The theoretical reference framework was identified in the constructivist and post rationalist view [17],[18].This effectively expresses concepts further emphasized by Ricoeur [37] and Morin [28] about the relativity of individual reality captured through a reading lens that is in a large part subjective, and in which emotional and affective components are even more critical than rational ones. Beside the literature analysis, we further developed our concept by adding a collection of requirements gathered through interviews with a panel of users already oriented to the collection of personal data, which will be described in the next section.

3 Panel Interviews

The purpose of the interviews was to collect design requirements from interested parties who have significant experience of self-logging, and who are thus accustomed to using logging tools during their daily activities. This allowed us to obtain results based on the actual and consolidated experiences of loggers, which is fundamental to integrating theoretical aspects. As a cross-cultural generalizability of other studies is equivocal, this work was also motivated by the fact that there is no research on this topic in the context of Italian culture.

Recruitment. As an industrial project, it has been important to preserve the confidentiality of the work. People were therefore selected internally. Owing to the availability of a large database containing the names of colleagues willing to participate in experimental activities, an email was prepared in which the potential subject had the possibility to easily discriminate their suitability to participate in the interviews. The discriminant included the use of at least one web or mobile application, or wearable object for at least three months in the last 12 months (a list of commercial products with three examples for each category was given as an example, together with an empty field to list unexpected logging strategies). We obtained forty-six responses. The respondents were then asked to complete a more specific questionnaire about the type of logging activities performed. On this basis, we selected 12 subjects (10 men and 2 women) deemed suitable to participate in the interviews. We excluded all subjects who carried out logging on their digital life (e.g. *Twitter, Facebook, Klout,* etc.), because potentially biased towards the aims of the project. The final participants' areas of logging concerned daily physical activity (8/12), the duration and quality of sleep (3/12), health aspects (4/12), emotional aspects (1/12), weight (10/12), food (4/12), productivity (1/12), energy consumption (3/12), and location (9/12). Of the total, the majority (9/12) of the participants tracked more than one aspect in their life.

Procedure. The 12 selected colleagues were invited to a meeting room for an hour-long interview entitled *"Current experience of logging and future projections"*. The semi-structured interview was recorded. The purpose of the interview was explained to each participant as a means to collect requirements for a future system of Quantified Self / lifelogging. The first 15 minutes of the interview focused on the current use of lifelogging strategies with reference to the aims and limitations encountered. The remaining 45 minutes were focused on the "future" of lifelogging, and in particular on three aspects: data collection means, usage, utility and purpose of data collection, and return/rendering and interaction with these data. No compensation was provided.

Results. The results were derived from the subjects' most significant statements in a proper recording grid according to the three categories of investigation highlighted above. We then added an extra area of requirements which spontaneously emerged out of our investigation boundaries.

- **Data collection.** The data collection emerged as particularly critical. It has been underlined by all participants as currently any kind of data collection requires a large investment in both motivational and cognitive terms. Even the applications referred to as minimally invasive or with very low maintenance levels (e.g. *Jawbone* for sleep cycles or *Expereal* for emotional states) still require a certain level of "obsessiveness" to be used perpetually, especially when the novelty effect decreases. Also, it became apparent that not all types of data require the same level of commitment in the collection procedures. For instance, recording personal location through apps like *Moves* does not require much cognitive investment, whereas the collection of emotional states (via *MoodPanda, T2, Expereal*, etc.) becomes very

annoying and invasive after the first few days. In order to justify the widespread adoption of lifelogging activities, the relationship between investment and benefit was judged insufficient by all of the respondents, with the exception of a few specific tasks. As such, the need for greater simplicity and cognitive economy in data collection is emphasized.

- **Usage, utility, and purpose of data collection.** The purpose of self-tracking was not clearly verbalized in the context of the semi-structured interviews, but rather expressed as *"control over what I do"*, *"learn some things about me", " motivates me to..."*. The literature's focus on behavioral change did not appear to be evident, even if the emergence of a desire for "change" (not just limited to the personal behavior) arose as unifying factor. The relative satisfaction with systems dedicated to very specific activities (e.g. pedometers) emerged in this area; however, there was significant dissatisfaction with the possibility of correlating different variables (for example: *"what determines the quality of my sleep?"*,*"I always wonder if there is a correlation between what I eat and my headache?"*). Answers to this kind of question are not easy, unless extensive motivational investment is made in personal data management. Most of the respondents (8/12) expressed an unfulfilled need to be able to understand the relationship between variables as an indispensable element of knowledge. During the interviews, some loggers showed an implicit schema to organize the correlation between variables: a plot based on two primary variables (space and time *"what the moment was, and where I was?"*) to "host" any kind of secondary variables (mood, activity, food, etc.). This plot seems to provide a context in which all other data looks more manageable.
- **Rendering and interaction with data.** Most of the participants (10/12) were generally satisfied with the data rendering provided by the tools used (web and mobile apps). All the loggers stressed the importance of the aesthetic aspect (beside the functional one) as an element of satisfaction in the exploration of their data (*"It's so cool, when…"*). The aspect that generated dissatisfaction with over half (7/12) of the users was the in/ability to interact with the data. The preselected views and data aggregates were in fact seen by half of the users as facilitative (*"it is probably the best way to see my sleeping pattern"*), whereas the other half saw them as limiting additional levels of knowledge (*"I wish I could sum up my amount of deep sleep, eliminating incomplete measures"*).
- **Further aspects.** Some unsolicited, although somehow predictable, aspects of partial dissatisfaction with existing logging tools were highlighted during the interviews. The initial issues that emerged were privacy concerns about possible usage, actual confidentiality, and the management of personal data by third parties. This topic has been the subject of various interventions well beyond our expectations. Total control over personal data and its confidentiality was deemed an indispensable aspect for a wider adoption of personal informatics (*"what if these data are then sold to my medical insurance?"*).The second relevant issue has been the real-time topic, such as the fruition of personal data while it is generated. We believe that this issue has been prompted by the considerable recent media attention given to Google Glasses (spontaneously cited by half of the respondents). A possible personal data-driven scenario was mentioned extemporaneously by a few of the loggers, although with unclear formulations (beside sports performance).

These data allowed us to identify a number of key design principles that we tried to imprint with a single guide sentence favoring the strength of the message rather than the accuracy of the requirement.

- *Seamless Data Collection*
- *Foster Change*
- *Variables' Relationships*
- *Context: space-time plot*
- *Promote Data Interaction*
- *Privacy First*
- *Beautiful Appearance*
- *Real-Time Insight*

From these pillars, we started to develop all the components of the Specch.io technological framework, from data collection means to the integration platform and the data interaction interface.

4 The "Specch.io" Framework

From the scientific literature analysis briefly summarized above, as well as the requirements gathered during the interviews, we proceeded to develop a concept and a prototype integrating the knowledge collected from these two inputs. This represented an artifact that is able to collect personal data in a seamless (without any explicit user action) or semi-seamless (with a slight friction in daily activities) way; a platform capable of integrating these data and highlight correlations; and an object able to render personal life patterns in a beautiful, integrated, and rich manner.

Data collection and integration modules are still ongoing; as a result, we will focus on the description of the final rendering object, the one closest to the end user, and the one with the most theoretical and methodological implications.

5 "Specch.io": A Personal Data Renderer

We designed a tool for data rendering and interaction by starting with the requirements collected from lifeloggers and an analysis of the relevant literature, in particular on the functioning of our semantic memory, and the mechanisms of meaning generation and change derived from the recent literature in the field of cognitive sciences. A sort of personal "magic mirror", which we called *Specch.io* ("specchio" is the italian word for "mirror"). The metaphor of the mirror to access personal data suggests an intimate space for self-reflection, where we can spot things about our lives that we cannot see from a subjective point of view, comparable to the way in which we cannot see a mark on our nose if not by using a mirror. We know that as humans we are neither good recorders of our lives (human memory is a highly plastic and generative process), nor good interpreters of what happens to us (each reading is always biased by our interpretive schemes).

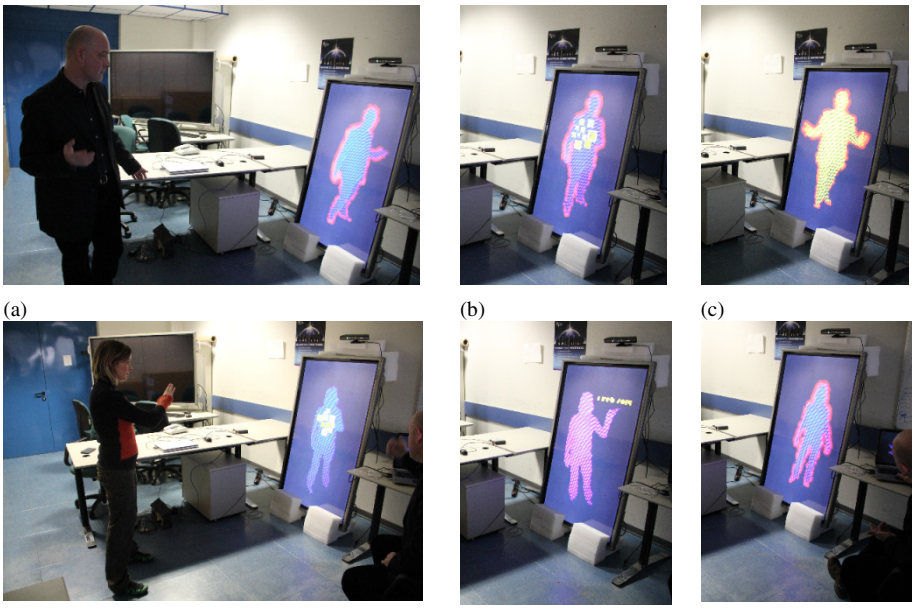

Fig. 1. Rendering and interaction with personal data in the "evocative" view. In the first sequence (a-b-c) the user access two different data set (a and c) activating and then "pushing" the squares on his body shape (b). In the second sequence (d-f-c) a different user "selects" a data set (d), then activates via gestures (f) a timeline in order to move backward to previous days data (g).

The idea to use such a powerful metaphor as the mirror was also drawn from a shared cultural imagination. Across time and cultures, the idea of a magic mirror is a recurrent theme in legends, fairy tales, and literary fiction. These fictional mirrors typically allow their users to see beyond mere reflected images, for example, by showing the true nature of oneself, revealing hidden knowledge, or opening portals for travelling to other worlds. Some well-known examples include the evil queen in the fairy tale Snow White who owns a magic mirror capable of giving a true answer to her questions; in Lewis Carroll's Through the Looking-Glass, and What Alice Found There [8], Alice, driven by curiosity, steps through a mirror to an alternative world; in J.R.R. Tolkien's The Lord of the Rings [43], Galadriel owns a magic mirror consisting of a basin filled with water, allowing her to see images from past, present, and future. These examples – among countless others – substantiate the magic mirror idea as a powerful, archetypal metaphor for the process of gaining insight into ourselves and raising self-awareness. Following these perspectives, the goal of Specch.io is the creation of an information visualization framework where personal data about the user can be shown in conjunction with a visual representation of the user's body in a seamless and immediate way. Placing her/himself in front of a device that behaves like a (magic) mirror, the user will see real-time visualizations of her/his data,

integrated with a mirror-like view of her/his body shape and movements. In our intentions, the joint visualization of the user's body and data should feel natural enough, and immediately recognizable and evocative, to give the user a feeling of immersion and engagement; at the same time, the look and behavior of the visualization's elements shouldn't be too realistic and predictable in order to stimulate a sense of wonder and curiosity about personal data. Ideally, this “magic mirror” should fulfill a role, like in fictional stories, of a portal to a world in which personal data visually reveals itself, and thus prepare the user to access more analytical data views. In fact, starting from this "evocative" vision (which can also be *per se* exhaustive) it would be possible to access a "synthetic" view where significant correlations are highlighted on a time/space plot, and even an "analytic" view where the user can manipulate the relationship between channels and create personal experiments for self-ethnography. There are therefore three levels of depth in *Specch.io* connected to different modes to access and use personal data.

5.1 Hardware and Software

Computational Framework
For our experiments on Specch.io concept, we've assembled a computational framework with the following hardware components:

- a Kinect sensor for 3D body data acquisition;
- a Sharp PN-L602B monitor standing in portrait orientation, for a mirror-like integrated display of body and personal data;
- a set of computational nodes for data processing and visualization (currently a single PC, which will evolve into a set of networked PCs).

The software components of the framework consist of a set of applications coordinating the data processing flow, which run the data analysis and visualization algorithms that embody our “magical mirror” concept. These applications are currently written in Processing [33], a programming language and development environment for creating images, animations and interactions. Some tasks are performed via the body data acquisition and analysis capabilities of the OpenNI and NITE libraries [32], which are wrapped into the simple-openni library [40] for their use within the Processing environment. A personal data feed component completes the magic mirror framework, providing access to the user's data. This data channel, currently implemented as a local database, will evolve into a networked data feed.

Data Processing Flow
A typical data processing flow in our “magic mirror” prototype unfolds as follows:

- The 3D sensor (Kinect) acquires information about the scene in front of the mirror in the form of a depth-map, i.e. a representation of the objects in the scene as a set of points in a 3D space;

- A scene analysis is performed (via the OpenNI and NITE libraries) in order to filter out all the depth-map points not belonging to humanoid shapes, thus keeping only the points belonging to the body of the user in front of the mirror (called "user map" in the following);
- A "skeleton" representation of the body is extracted (via the OpenNI and NITE libraries) from the user map in the form of a set of data encoding the position and orientation of the body's joints and limbs (called "user skeleton" in the following);
- An "outline" representation of the body is computed (via our framework's algorithms) in the form of a linked list of 2D points, delineating the body's outline from a 2D projection of the (3D) user map (called "user outline" in the following);
- Personal data about the user are retrieved from the personal data feed;
- A visualization is generated (via our framework's algorithms) from the user map, user skeleton, user outline and personal data; the visualization is rendered and displayed on the large monitor in front of the user.

Each of these steps (except for the personal data retrieval) is performed in real-time with a frame rate in the order of tens of frames per second, giving a fluid visual feedback that can be perceived by the user as a mirror-like experience.

Interaction and Animation

The Specch.io visualizations can often benefit from the presence of interactive features, exploiting user skeleton information for limb position detection (e.g. hand position detection) and gesture recognition. Natural movements allow the user to focus on specific visualization elements chosen from among various different personal data sets and visualization designs, and switch between the "evocative", the "synthetic", and the "analytic" view.

Moreover, the real-time nature of the framework makes animation an interesting feature, both as an informative visualization element and as a transition effect.

An example of the joint use of interaction and animation is the set of ways of leaving the mirror we're experimenting with. In one of these, when the user suddenly opens wide her/his arms, the gesture is recognized as the intention of leaving the "evocative" view. This triggers an animation effect that penetrates the visualized body shape, simultaneously fading the screen to black and preparing the emerging of the "synthetic" view. The reverse animation – re-integrating the body's shape – can be used when the "evocative" view is requested back.

6 Future Works

As a technological framework Specch.io is evolving to integrate different data feeds from both Quantified Self gadgets already on the market today (Fitbit, Jawbone, etc.) both from channels that are currently not collected in a sufficiently seamless manner (i.e. mood, heart rate, etc.) and for which we are developing ad hoc collection techniques. An additional roadmap concerns the data integration platform, and the inclusion of reasoning processes able to provide significant correlations between events.

As a data rendering interface, *Specch.io* will involve the envisioning and implementation of a specific set of InfoVis designs and algorithms on the three levels of data interaction ("evocative", "synthetic", and "analytic" view). Due to the peculiar nature of the *Specch.io* concept, a common and important aspect of these designs will be the interplay between the visualization of personal data, and the rendering of the user's body shape and movements. Several possibilities will be explored concerning the possible rendering of data in the visualized body:

1. "Tattoo" behavior: where the position of InfoVis elements closely follow the body's movements, as though they were tattooed or painted on the body surface.
2. "Projection" behavior: where InfoVis elements independently "live" and move in their own space, and appear as if they were projected on the body's surface.
3. A behavior somewhere in-between the previous two, where, for example, the InfoVis elements behave a bit like they were projected, but are also constrained to stay within the body's outline.
4. More complex behaviors, with a deep interplay between the shape/movements of the body and shape, position, and movements of InfoVis elements. This will be the most challenging case.

7 Conclusions

Many users are already familiar with Quantified Self and Personal Informatics applications in emerging vertical sectors directed to specific tasks, such as Nike+, Fitbit, Moodscope, Mint, etc. The scenario for tomorrow's Quantified Self instead aims at something beyond this: a possible integration between different aspects of life that are now discrete (e.g. location + mood + sleep + fitness + health + food + work), thanks to the ever-increasing possibility of sensing, seamless logging, and evolution of intelligent systems able to examine correlations between vastly different data sets. A scenario in which being connected becomes an implicit and imperceptible task generating value, meaning, and knowledge for the user. The purpose of the Specch.io framework is just that: to go from numbers to patterns, from "how" to "why".

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