Enhanced Reflection to Encourage Healthy Living

Ana C. Andrés del Valle and Agata Opalach
Accenture Technology Labs
449 rt des Crêtes – BP 99
06902 Sophia Antipolis - France
+33 4929 {47523} {6736}
{ana.c.andresdelvalle}{agata.opalach}@accenture.com

ABSTRACT
In this paper, we present the Persuasive Mirror, an example of persuasive technology, created at the Accenture Technology Labs, which aims at encouraging people to keep up a healthy lifestyle. Personal reflection and visual awareness of daily activity are the means used to motivate people to do regular exercise and eat sensibly.

Categories and Subject Descriptors
H.1.2 [**Information Interfaces and Presentation**]: User/Machine Systems – *human factors, software psychology*. H.5.1 [**Information Interfaces and Presentation**]: Multimedia Information Systems – *artificial, augmented, and virtual reality, video.* H.5.2 [**Information Interfaces and Presentation**]: Prototyping – *user-centered design*. J.4 [**Social and Behavioral Sciences**]: *psychology, sociology.*

General Terms
Design, Experimentation, Human Factors.

Keywords
Computerized persuasion, activity monitoring, computer vision.

1. INTRODUCTION
Ancient cultures were already aware of the tight relationship between body and mind ("[…] *mens sana in copore sano*" [1]) We should then give **fitness** a meaning beyond the classical definition that restrains it to "good physical condition". Indeed, this new conception would follow the World Health Organization description of Health as the "*state of complete physical, mental and social well-being and not merely the absence of disease or infirmity*" [2]. Within this context, **fitness** is the equivalent to "good global condition".

Under this framework, it is easy to understand the psychological struggle that people willing to do exercise and have a healthy life undergo. Often, the activities that "please our minds" do not match those that are "healthy for our body". It seems, therefore, that psychological support might be needed to help people that at some moment in time are determined to change their habits because they want to improve their quality of life.

"*We, as humans, primarily learn to be the way we are; therefore, at any point in life we can learn to be different. But, it may not be easy to change* […]"[3] Indeed, it seems that changing is difficult as many of those who want to change look for help in doctors, professional coachers, psychologists, or, if they want to do it by themselves, from personal self-help advice. For instance, to understand the concern that changing behavior raises in the United States, we will cite that in 1998, one out of ten books sold in the US was related to self-help –*The Wall Street journal, December 8, 1998.* Many of these books are about dieting, exercising, and healthy living.

Computerized persuasion, or captology, is the study of computers as persuasive technologies [4]. It explores the design and applications of interactive products created for the purpose of changing people attitudes or behaviors in some way. To provide a daily motivation aide to individuals willing to have a healthier lifestyle, we have conceived a "nagging" object that uses sensor data about our behavior, analyses them with relation to our goals, rewards good and exposes bad behavior. Psychological studies show that often simply observing our behavior may persuade us to change it [3]. We considered several physical forms to give shape to the concept, and finally decided to use a mirror: the Persuasive Mirror.

This article describes the concept and the technical challenges behind designing and developing the Persuasive Mirror. In the next section, we describe the suitability of such a device as a personal "fitness coach". Section 3 includes the technical challenges. We discuss the social concerns that our persuasive device could raise in Section 4. Finally, in Section 5, we conclude with future perspectives.

2. CONTEXT
The conception of the Persuasive Mirror derived from research done within Accenture's Intelligent Home Services initiative [5]. This initiative aims at enabling the elderly to age autonomously at home. To allow older people stay fit, specific coaching could be given in the form of visual feedback. In an environment where artificial intelligence and sensors will be deployed all over the home [6][7][8], this mirror would become a personal coach.

Ubiquitous sensors continuously gather information about our behavior. However resulting data are generally used by a third party. Yet, the monitored person could take advantage of them in their daily life. People use a mirror daily and often more than once. The choice of a mirror as the object onto which we add persuasive capabilities seems natural. A mirror suits well the

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persuading purpose because humans are mostly receptive to visual stimuli, over auditory or tactile. The natural reflection from a mirror already presents information upon which people react. This information, the face reflection, can be enhanced to provoke some user's reaction. The Persuasive Mirror will take advantage of the convergence of visual feedback of the person's daily behavior in the least intrusive manner.

Besides exposing the user's actions, the mirror will set realistic goals to him. At defining these goals, related to the user's willingness to stay fit, the Persuasive Mirror will consider first, that success in attaining short-term challenges generates motivation; and second, that setting expectations beyond the user's capabilities decreases it. The mirror will visually reward the desired behavior while ignoring of punishing the unwanted activity. Table 1 presents examples of reinforcement versus punishment strategies. Negative reinforcement strengthens the previous behavior and punishment reduces or stops it. Depending on the user's psychological appreciation, some strategies are more efficient than others. The Persuasive Mirror will adapt its reflection to the user's activity evolution.

Table 1. Reinforcement versus Punishment [3].

	Positive	**Negative**
Reinforcement	Giving or getting something pleasant, e.g. a weekly pay check or a compliment	Taking away or avoiding something unpleasant, e.g. avoiding stress/pain by not going to a dentist
Punishment	Administering or receiving something unpleasant, e.g. being fired or spanked, or getting an "F"	Taking away or being deprived of something pleasant, e.g. being denied TV or fun activity or the car

3. TECHNICAL CHALLENGES

"*Mrs. Novak knows that regular exercise and a balanced diet is good for her both in the short and in the longer term. However, in her day to day life she often forgets to include a walk and usually prepares the same quick and not always nutritionally balanced meals. She wishes she had a personal coach who would help her vary the recipes while keeping them simple (she no longer has the patience to prepare elaborated dishes) and to help her stick to regular exercise. She buys a Persuasive Mirror and has it configured to match her nutritional and fitness goals.*

One morning, when Mrs. Novak brushes her teeth, her Persuasive Mirror shows a healthy looking face and displays a reminder that she has a doctor's appointment at 10am. It also confirms that the weather forecast is good and suggests she takes a stroll to the doctor's office. In the evening, Mrs. Novak finds that her face looks more tired than usual. With a wave of a hand she sees detailed statistics on the behavior that day: that's right, she drove to the clinic and had a frozen pizza for dinner, ignoring the system's suggestion for a salad with ham and pine nuts…

A year later, Mrs. Novak is very happy with her increased energy, surely due to the regular exercise she now has and her balanced diet. She half-laughingly maintains that her healthy lifestyle is "to keep her mirror happy" but she is also proud to announce to her daughter that her doctor confirmed osteoporosis improvement so she can take up dance classes again at her senior club."

This scenario shows how the Persuasive Mirror is an augmented mirror with three working modes: 1) progress representation, showing feedback on recent behavior (e.g. silhouette slimmer and younger for a balanced meal, bigger and older for no meal or junk food), 2) behavior summary (statistics on "good" and "bad" behavior, areas to improve), and 3) a regular mirror (equivalent to switching the device off). Next, we detail the main technical challenges.

3.1 Creation of a Digital Mirror

Recently, hardware-based mirror-like displays have appeared on the market. For example, the television/mirrors by [9] and [10] are digital screens that also reflect in a mirror style. Parallel to this hardware evolution, researchers in the Computer Vision field have been studying using mirror reflection as a way of enhancing displays. Mirroring adds utility value to the passive nature of displays. In [11], some researchers replicate mirror effects in software using a half-silvered mirror hardware setup. They then detect faces in the image and deform them in real-time, offering an engaging interface. We can also use a software solution to mix generic video input or user screen with the images acquired by camera facing the user [12]. In particular, such interface is useful in tele-guidance applications. The i-mirror [13] imitates a mirror using a dedicated optical system. They explore potential uses of such a setup, including a mirror with gain that show images even in dark environments, a look-younger/older mirror and a mirror with memory. More recent works focus on finding more compact mirror-replications. In [14] the authors expose how a portable display system can be used to create a mirror. Some other recent works have started to experiment with the implications of manipulating people's reflections on the screen. For instance, the Mirror Space [15] is made of a one way mirrored film mounted onto a glass surface, a USB camera and a sensor, and is linked to other mirrors located elsewhere. It captures whoever is in front of the mirrors and superimposes the live-streamed video, so that all the faces can merge in the same space. In [16], a responsive virtual mirror for interpersonal communication is proposed. It exposes people who are having a remote conversation as if they were all reflected on a mirror and controls the intensity of the reflection depending on who is speaking.

Figure 1 illustrates the physics behind replicating a mirror reflection with video input. The goal of the system is to simulate the image coming from a camera located in the "virtual view-point" symmetrical to the user over the mirror/screen. The "virtual viewpoint" is mobile, because it follows the person, but any camera used will be fixed around the screen. To reduce occlusions at least two cameras will have to be utilized.

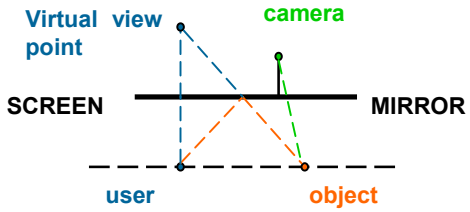

Figure 1. Diagram of mirror simulation with one camera.

In Figure 2, we show the Persuasive Mirror's current hardware settings. To obtain one coherent image from two camera inputs, we have based our solution on a system that restitutes views from two cameras corrected for videoconferencing [17]. We have optimized it to work in real-time with very high resolution images and to suit our mirror requirements. To change the final camera viewpoint and enhance the face reflection, we need to know the face location on the digital reproduction. We have started to work

with Active Appearance Models [18][19] that have proved to give good results not to only localizing the head on the image but also determining where the facial features are.

Figure 2. Inside the first prototype of the Persuasive Mirror.

3.2 Create the Visual Feedback Mechanism

Image enhancements are essential to provide visual feedback. They can go from intelligently exposing data, to altering the user face appearance according to the effect we want to produce and the message we want to convey. For instance, morphing techniques like Face Transformer [20] can be used to render the face younger or older. Subtle reminders of the consequences of the user's behavior can also be conveyed by artificially playing with colors, non-photorealistic rendering or augmented reality techniques. Other possibilities are to use augmented reality (mixed reality) techniques in order to add artificial elements into the scene. An additional difficulty in this case is to match the lighting on the artificial elements and the lighting of the real scene in order to make the additions believable.

We plan to experiment with several enhancements in order to evaluate which one is most effective for any particular user. One general outcome of not doing exercise and failing to stay fit is the gain of weight. As a first enhancement, we are developing image processing algorithms based on Active Appearance Models, facial-anatomical deformation constrains [21] and skin color changes to show the user the consequences of unhealthy habits on his reflection before they happen (e.g. fattening).

3.3 Collect and Analyze Activity Data

Ubiquitous sensors located on the person or in his home can generate data that permit to study the person's activities and behavior [22].

As a first step, we have investigated how health-tracking personal sensors can be used to derive information about the user's activities related to his/her lifestyle. There are several emerging technologies that allow an insight into a person's lifestyle, for example digital exercise coaches like PAM [23] or Healthwear [24]. A host of physiological data can also be gathered using wearable sensors, like a Lifeshirt [25]. Finally, a variety of digital scales is available [26] to measure both weight and body fat.

The aforementioned systems have a major drawback; they must be always worn to be able to provide relevant data about the user's health habits and evolution. Least intrusive systems could be as helpful. For instance, for an insight into eating habits, a future smart fridge could be used, scanning all products going in and out of the fridge. A camera-based system could be deployed, as an indoor solution, to monitor how active a person is at home [27].

A sensible combination of these sensor systems will provide the data that will be used to evaluate the evolution of the user. The mirror will give a certain visual feedback based on this evolution.

3.4 Design a Feedback Strategy

In order for the mirror to perform its persuasive role, the visual feedback given will have to match the psychological strategy aimed at creating the wanted reaction in the user. The goal of designing a persuasion strategy is motivating the mirror's owner to have a healthier lifestyle. Let us stress that the mirror has no pre-encoded universal values it tries to impose on the user. It is the user that configures the device in order to receive daily assistance in achieving their goals.

Some of the psychological concepts we would like to take into account are [28]:

- **Punishment versus reward**: the mirror reflection is able to present the future consequences of a certain behavior. It will show the bad results of not behaving appropriately versus the good results of acting correctly. The objective being that the user will be motivated by seeing that a change in behavior really matters.
- **Likes and dislikes**: people have more positive or negative preferences to certain colors, shapes, and visual structures. The mirror could take advantage of that by relating the visual environment the user's likes and dislikes. Likes will be attached to positive behavior; dislikes to negative.
- **Positive reinforcement** [29]: is the technique used to encourage people to start having or maintain a certain behavior by reminding them how good it is to them (positive feedback) but also how it can still be improved (by letting them know that the final goal is getting closer). Once a certain positive behavior has appeared, it is challenging to maintain the interest of the user in continuing acting appropriately. A punishment versus reward strategy has proved not to be always optimal because continuous reminders about future negative consequences might discourage people. That is why the all strategies have to be integrated inside a positive reinforcement framework.

Based on the classification of captological devices given by Fogg [4], the Persuasive Mirror can be seen as a persuasive social actor –using attractiveness, similarity, reciprocity and authority visual suggestions, and as a simulation media –showing cause and effect, virtual rewards, etc.

No individual is and reacts alike, the adaptation and customization of the Persuasive Mirror to the user's profile is a major challenge. The processing will have to be adapted to the individual because what motivates people is a very personal matter. We propose to proceed incrementally, offering very slight comments first and exaggerating them on request from the user until the optimal configuration is achieved.

4. CONTROVERSIAL ISSUES

Any computerized system provokes the same initial fear: "*Can we trust a computer?*" This concern becomes even stronger when the device performs critical tasks. The Persuasive Mirror could play a major role in the user's life. The owner of the mirror will have to be reassured that its operation is correct and that, above all, is completely fault tolerant. This fault-tolerance is an important part of the system as the effectiveness of the device will be determined by the correct processing of the input data.

Beyond the natural fears associated with technology, the use of persuasive devices raises ethical concerns regarding their potential to drive people to act in a certain manner. As it happens with any technology, its uses and abuses must be evaluated. Like self-help books, we believe that if it is used with explicit consent, the outcomes can be beneficial to the user. Once the prototype device will be developed, we plan to perform user studies in collaboration with psychology experts so to assess how the Persuasive Mirror influences human behavior. We are currently looking for psychology researchers interested in such an evaluation.

5. CONCLUSIONS

Fitness should be considered the optimal maintenance of global human condition. Mind and body work together to make people stay fit. Often psychological support eases the task of keeping up a healthy lifestyle. The Persuasive Mirror is a persuasive device that tries to prove that computers could provide the required support.

This work is relevant to research areas studying the challenges of how ubiquitous computing can help fitness and health-related activities be easily accepted by regular people that currently have a very hard time changing their unhealthy behavior

Researchers at the Accenture Technology Labs have been mainly focused on the technical challenges. We are also interested in finding what psychological strategies are the most suitable. We would like to discuss and collaborate with people who have already had experience doing research in this field.

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