

Proposing Daily Visual Feedback as an Aide to Reach Personal Goals

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Abstract. Personal goals are difficult to achieve and healthy habits are not as simple to maintain as people would like to. Often, humans look for help to change unwanted behavior. Technology could help us to overcome the daily struggle faced during the search for behavior improvement. The Persuasive Mirror is an example of how computerize persuasion, in the form of visual feedback, could give the needed support.

1 Introduction

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.

Mrs. Novak's story represents one of the scenarios where a Persuasive Mirror [2], Accenture Technology Labs concept mirror that gives personalized feedback

to the user in order to persuade him to pursue certain goals, could be beneficial. Very often, people undergo psychological struggle when willing to keep up a healthy and reasonable lifestyle. Often, the activities that "please our minds" do not match those that are "healthy for our body". Changing unwanted behavior has become a concern. For instance, in 1998, one out of ten books sold in the US was related to self-help – *The Wall Street Journal*, December 8, 1998. 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.

The Persuasive Mirror is a fine example of computerized persuasion. Computerized persuasion or *captology*, is the study of computers as persuasive technologies [9]. It explores the design and applications of interactive products created for the purpose of changing people attitudes or behaviors in some way. The *captology* efficiency of a piece of technology is strongly related to the capability that its interface has to impact the user. Ideally, the selected technology has to be non-intrusive, often used and able to provide the user with relevant feedback linked to the activities he is concerned about. We considered several physical forms to give shape to the concept, and finally decided to use a mirror because it is a natural object in people's life and it is generally used more than once a day. The Persuasive Mirror provides daily motivation aide to individuals because it is a "nagging" object that uses sensors to gather information about our behavior, analyzes these data with relation to our goals, and visually rewards good and exposes bad behavior.

Next Section contains an overview of the Persuasive Mirror architecture. We go over the technical challenges of replicating a mirror using digital reflection in Section 3. In Section 4, we review several useful visual feedback that could be used. Sections 5 and 6 cover social aspects related to the persuading nature of the mirror. First, we discuss some of the psychological strategies relevant to our work; second, we expose how the system needs to be customized to every user's characteristics and goals. We conclude our article by discussing some future work.

2 Overview of the Persuasive Mirror Architecture

The Persuasive Mirror is an augmented mirror that we have designed 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).

Fig. 1 depicts the architecture behind the device. Three modules integrate the system:

Sensor network: Sensors are the backbone of any intelligent technology. The sensor network plays a critical role in the architecture because it gathers information about human activity in various ways. The mirror reflection is

designed based upon the user's behavior. Activity related to health habits can be observed, for instance, using video cameras [1], that study global activity; UV cameras that analyze sun damage of the skin; vital signal analyzers; smart fridges that control the amount of food that is taken from them; or, smart balances, that not only measure mass but also give out the percentage of fat contained in our bodies.

Control system: The control system can be considered the brain of the Persuasive Mirror. It acts as a bridge between what the person does and what the mirror provides as a feedback. Upon receiving the data from the sensor network it must decide the kind of visual feedback the digital mirror will give to the user. As we explain in Sections 5 and 6, there is no universal strategy for persuasion that can be applied to everyone. In fact, the control of the mirror is the result of complex customization of the global system based on the experts advice about health and psychological influence. The mirror is a user-centered designed device, therefore, the control system will require the feedback of the user's evolution and reaction from the moment the device is utilized.

Digital mirror: Altered visual feedback of our own face can have great impact on us. In order to be able to give customized reflection a flexible digital mirror has been created. The digital mirror not only works as a regular mirror but also enhances the user's face thanks to different Image Processing techniques.

The complete architecture allows the Persuasive Mirror to act accordingly to the user's goals and behavior.

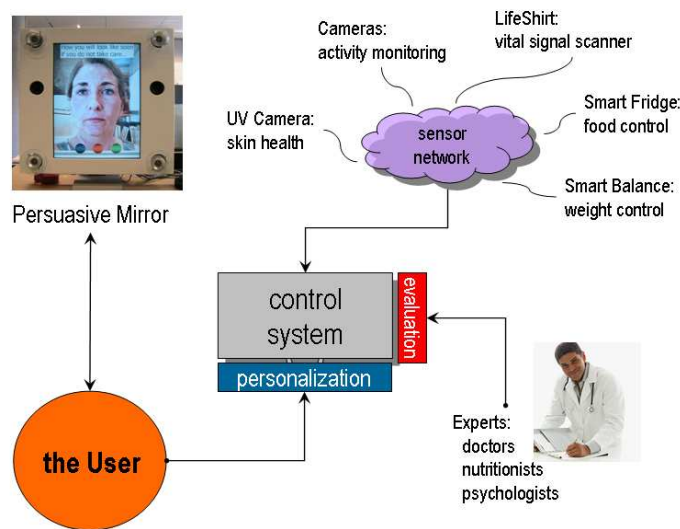


Fig. 1. The Persuasive Mirror architecture

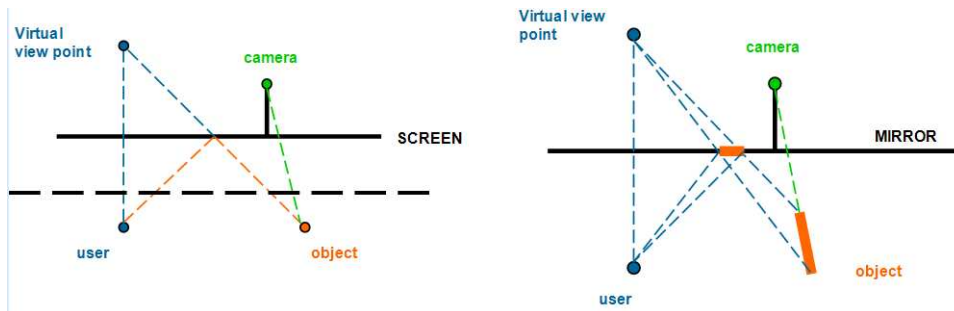


Fig. 2. These diagrams show how the mirror reflection can be simulated (left) and the limitations of using a single fixed camera because of the occlusions.

3 Digital Replication of a Mirror

The first technical challenge faced was to create a system that replicates a mirror. This challenge involves several geometrical and computational aspects that have to be solved. When somebody is looking at a mirror, he can see the scene from different viewpoints, depending on his position. To replicate the reflection, this viewpoint can be obtained by rendering the image from a virtual camera whose position is symmetric to the user over the mirror axe.

Taking into consideration these geometrical aspects, some researchers at the University of Southern California [10] developed one approach, using a tracker and a single camera. The tracker returns the relative position of the face. Then the system knows what part of the scene given by the camera has to be displayed on the screen. Nevertheless, as read in the previous articles, some regions that have to be displayed might be occluded to the camera (Fig. 2). Therefore, to avoid occlusions, we should use more than one camera. In our particular case, to use the simplest settings, we have decided to use two cameras situated on the left and right sides of a screen. Our prototype is pictured in Fig. 3.

Starting from this configuration, we will have to solve two main problems. First we need to track the eyes of the user. A real time technique has been developed by Darrell et al. [7]. Applying usual tracking techniques on the output of two cameras, the 3D position of the face is computed by triangulation. It is also possible, as shown in [15], to not only find the eyes position but also the gaze direction.

The second issue is to derive a single image that describes the scene from the right viewpoint using two cameras. One way to achieve this goal is described in [4]. Several cameras are used to display one defined target in the scene. For each camera, a list of penalties due to several parameters, like the distance to the target or the resolution of the camera, is defined. Then, in the final image, every pixel is coming from the corresponding best camera. A second approach is described by Criminisi et al. [6]. The developers use only two cameras, and



Fig. 3. Components of the digital mirror: two cameras, one touch screen and some lights.

apply a modified Dynamic Programming (DP) algorithm to compare the images. Using defined cost functions, the DP algorithm computes for each line of the 2 images the best alignment called the minimum cost path. Every pixel of this path is projected on the 45-degree line called the "virtual scanline" using the position of the virtual camera, defined for replication as a center of projection.

Finally we can see in [3] a large study of the most used algorithms in stereo computing. Local methods like "Block Matching" or "Feature Matching" compute a pixel by pixel matching. These methods are very fast but several artifacts appear due to occlusions. Global Methods like "Graph Cuts" or "Dynamic Programming" compute global matching. The results are better but these methods are more computationally expensive.

After evaluating the current state of the art, we decided to extend the work of [6] to mix our 2 inputs. The DP algorithm seems to give acceptable results and we have specially adapted it for real-time applications. We will also use triangulation in order to compute the 3D position of the eyes that will define the location of the virtual camera.

4 Advanced Image Processing to Generate Feedback Enhancements

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 [8] 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.

Experimentation is needed to evaluate which enhancements are the most effective for any particular user. One general outcome of not doing exercise and failing to have a healthy lifestyle is the gain of weight. As a first enhancement, we are developing image processing algorithms based on Active Appearance Models, facial-anatomical deformation constrains [17] and skin color changes to show the user the consequences of unhealthy habits on his reflection before they happen (e.g. fattening).

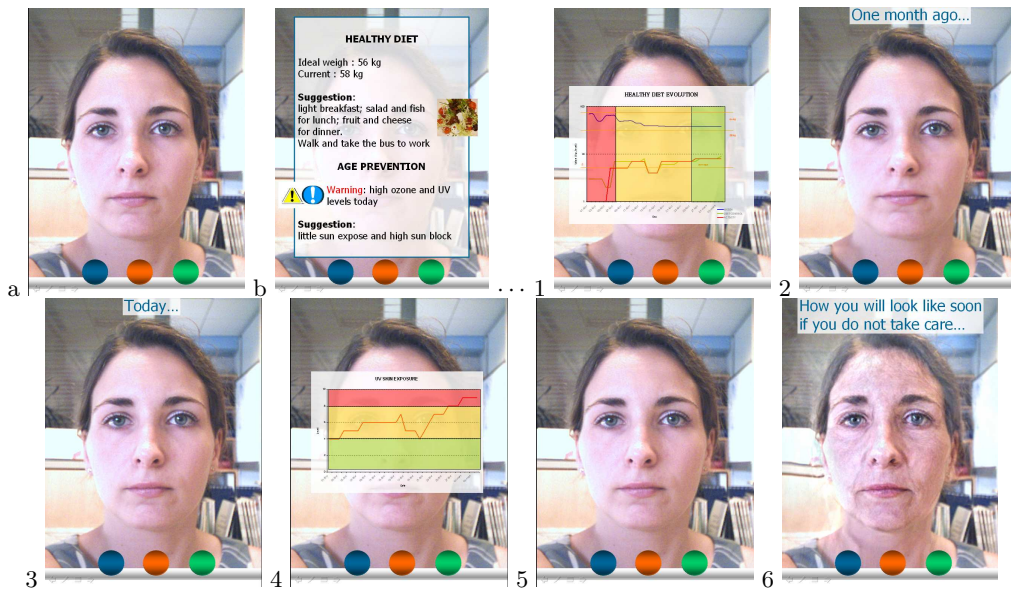


Fig. 4. A time line example of the reflection the user will get with the Persuasive Mirror. In the morning (a-b), suggestions will be given according to the user's personal goals. At night, the mirror will review the user's activities regarding the proposed suggestions; it will give visual feedback to let the user understand the consequences of her acts.

5 Psychological Strategies to Achieve Persuasion

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 [5]:

- **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:** [16] 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.

Fig. 4 presents an example of how the mirror could change the perception of our activities by showing us the consequences of our acts. In this case, the mirror has two different attitudes: (a) a controlled diet has allowed the user to lose those kilos she did not want, and the mirror reminds her the progress she has made (*positive reinforcement*); and (b) the user has been under the sun without protection and has not followed the mirror’s advice, the mirror shows her the future consequences of her unhealthy act (*punishment & dislikes*).

6 Personalization to the User’s Needs

Most processing steps behind the mirror will have to be adapted to each individual using it because what motivates people is a very personal matter. Given a set of psychological strategies and a certain number of persuading visual-enhancement techniques, the Persuasive Mirror system has to be tuned to apply those that will effectively persuade the user. No individual is and reacts alike, the adaptation and customization of the Persuasive Mirror to the user’s profile is a major issue.

The technical challenge in the customization field is to build a system that automatically configures to the user requirements with little (ideally none) user interaction. As a starting point in our research, we propose to proceed incrementally, offering very slight comments first and exaggerating them on request from the user until the optimal configuration is achieved. Eventually, previous knowledge about the user’s taste and psychology could help to speed up this customization stage.

7 Conclusions and Future Work

The Persuasive Mirror was conceived as part of the Accenture's Intelligent Home Services initiative [12]. This initiative aims at enabling the elderly to age autonomously at home. To allow older people stay healthy, specific coaching can be given in the form of visual feedback. In an environment where artificial intelligence and sensors will be deployed all over the home [13], [14], [11], this mirror would become a personal coach.

The Persuasive Mirror is a visually enhanced display that alters people's reflection to motivate reactions and change in behavior. We believe that computerized persuasion delivered by such a device can help the users reach their personal goals. Interface design is central in captology devices. It becomes even more crucial if the interaction between the device and the person aims at producing a change in the user's behavior.

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, it 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.

Researchers at the Accenture Technology Labs have been mainly focused on the technical challenges. Our future research lines will include how to create the automatic personalization of the mirror feedback. Automatic customization of technology can be of great interest to different industries.

We are also interested in finding what psychological strategies are the most suitable. We want to establish collaborations with experts in the medical and psychology areas. They could help us perform field studies that could shape the strategies behind the Persuasive Mirror.

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