Anti-hedonistic machines

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ANTI-HEDONISTIC MACHINES

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ABSTRACT

This paper is devoted to the concept of Anti-Hedonistic Machines (AHMs) interacting with humans. Up to this time, people developed machines and artefacts which could enhance the level of perceived pleasure (e.g. entertainment tools, communication networks, virtual reality systems) or technologies which could reduce human efforts and pain during specific heavy and repetitive tasks, "helping people doing something" (e.g. robotic, automated and intelligent systems). In recent years, examples of machines designed to "prevent people from doing something" are emerging. Such machines can be defined as anti-hedonistic machines or, more generally, anti-hedonistic artefacts. For example, intra-gastric balloons prevent people from eating, timed cigarette boxes prevent people from smoking, special bracelets (reminders) prevent people from onychophagia, and alcohol-testers connected to car starters prevent people from driving under the influence of alcohol. This work presents a general framework for anti-hedonistic machines and systems, providing general definitions and a possible classification.

Keywords: Anti-Hedonistic Machine, Human-Machine Interaction, biomechanics, precommitment

1 INTRODUCTION

In the field of Human-Machine Interaction (HMI), the term *Anti-Hedonistic Machines* (AHMs) refers to a new kind of machines and mechatronic systems designed to prevent people from feeling immediate pleasure. In other words, AHMs should be able to limit or inhibit the chance to reach an immediate and instinctive pleasure.

Every AHM needs the user to be aware about the aim of the machine itself before starting to use it. The initial awareness is fundamental for the correct functioning and efficiency of such a machine. In fact, people using AHMs need to know that, in a short time, their willpower will weaken and have to accept in advance the deprivation effects and the discomfort conditions which the machine would cause to them.

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This concept may be explained through the myth of Ulysses [1] [2] [3] [4]. According to the myth, the Greek warrior ordered to the crew to be tied to the mast when his mind was still clear, in order to avoid to succumb to siren flatteries (immediate and instinctive pleasure) when his mind would have been benighted.

Another example can be taken from Italian literature. It is known about the firm decision of Vittorio Alfieri, who ordered his servant to tie him to his chair for the purpose of completing, as soon as possible, the tragedy he was writing. The playwright in fact kept putting off the tragedy writing because of his attractions for other pleasure situations (he had an irrepressible attraction for Marchesa Turinetti di Prie) [5]. In both Ulysses' and Alfieri's examples it is possible to identify the rope as a rudimental but efficient example of AHM.

Taking advantage of an artefact planned in the present to modify or restrict someone's freedom of choice in the future is a concept that attracted considerable interest in the last few years, in particular referring to the notion of *precommitment* [3] [4] [6]. Using an AHM could be read as the outsourcing of a person own willpower: to delegate out of the mind choices which could be advantageous in the long future.

This paper is an extended version of a preliminary conference report that was presented at IFIT 2016 [7]. The paper is organized as follows: in Section 2 the Anti-

Hedonistic Machine concept is explained through the point of view of the *mismatch theory*, in Section 3 the main operating principles of such machines are presented and in Section 4 a possible classification (non-exhaustive) is provided. Section 5 reports two examples of AHMs: a push-ups exercises mechatronic system and a weight scale based on the *panopticon* principle. Finally, the conclusions of this work are given in Section 6.

2 MISMATCH THEORY: AN EVOLUTIONARY EXPLANATION

In order to better understand the anthropological origin of Anti-Hedonistic Machines, it is necessary to attempt to justify their origin from an evolutionary point of view. In the field of evolutionary psychology, which deals with evolutionary origins of particular human behaviours, the concept of *mismatch theory* has been introduced [8] [9] [10]. In particular, this theory is based on the fact that an individual has characteristic features, both biological and cognitive, as well as instinctive, that are the result of a matching process in a particular environment. The regulation of the adaptation is carried out thanks to the maximization of the *fitness*, term that in biological science identifies the reproductive success of a living being. The adaptation process is really slow and it might happen that the environment, in which the individual lives, modifies its features in such fast timescales that the individual cannot longer adapt itself. In these cases, a mismatch between the hereditary features of the individual (fitted for a past environment) and the actual environment (unsuitable for those characters) arises.

An interesting example of the mismatch theory is given by the instinct of the human being to feed itself with fat and sugar-rich food. Such instinct emerged thousand years ago, when the natural environment was lacking in alimentary resources (see top of Figure 1). The balancing between the environment and the instinct realized an equilibrium that ensured a profitable body-weight. As soon as the human being changed its natural environment, by overcoming the predators and, therefore, the lack of resources, this equilibrium has been lost. The result of this mismatch has been the phenomenon of obesity (see centre of Fig. 1) [11].

Nowadays, one of the technologies to treat the obesity is the intra-gastric balloon, which consists in a balloon which partially fills the stomach and limits the food intake [12]. It provides a sense of satiety to the subject and, therefore, it supresses the eating desire. The intra-gastric balloon certainly constitutes an AHM developed to recover the imbalance caused by *evolutionary mismatch*: the mismatch between hereditary features of individuals, which are adapted for a past resource-poor environment, and the present context, unfit for that hereditary features (bottom of Figure 1).

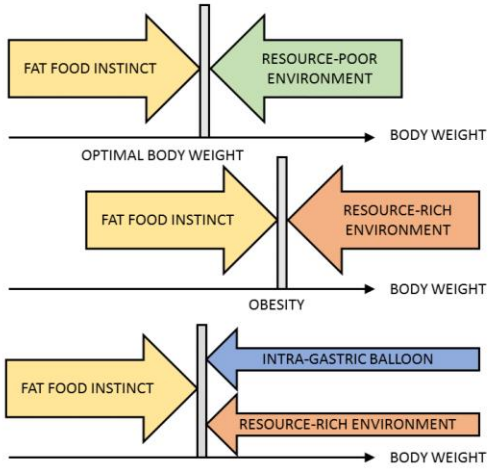

Figure 1: Evolutionary mismatch between hereditary features and environment.

3 OPERATING PRINCIPLES

To better understand AHMs operating principles first of all it is necessary to consider that every time individuals have to make a choice, they assign a value to all the possible alternatives they have. In most cases the perceived value associated to a reward dacays according to the delay with which it is possible to benefit from the reward [13] [14]. This concept is explained in Figure 2. The horizontal axis indicates the reward delay, whereas the vertical one reports the amount of value perceived for that same reward. The more the delay increases, the more the perceived value is affected by a higher *temporal discount*.

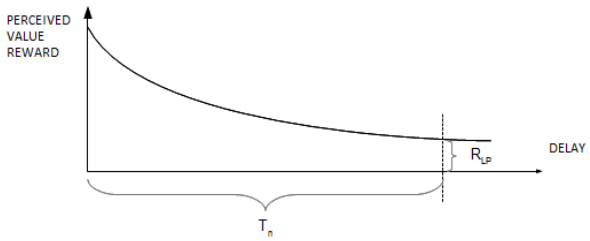

Figure 2: Temporal discounting, perceived value reward over time.

If an artefact or a machine interacts with individuals to change their own choices and make the precommitment effective, not only the temporal discount, but also the costs, which the subjects have to pay to reach the reward, should be taken into account [15].

For example, going to the gym is for many people a way to gain an excellent physical condition, which is the reward pursued by them in the long term. The value perceived from this reward is not constant over time but it is subjected to a temporal discount. In fact, if only it was enough to do a single exercise to gain the perfect physical condition, the value perceived from the reward would be great. On the other side, if it was need to do exercises for years this value would definitely decrease. In particular, the decrease of this

value is proportional to the delay with which the result would appear.

To further explain AHM's role in precommitment scheme, the curve of temporal discounting, symmetrical to the vertical axis, is used (Figure 3). In this case, the value R_{LP} (long-period reward) in $t = 0$ represents the discounted value of the reward for a delay equal to T_n, which is the value assigned to the perfect physical condition.

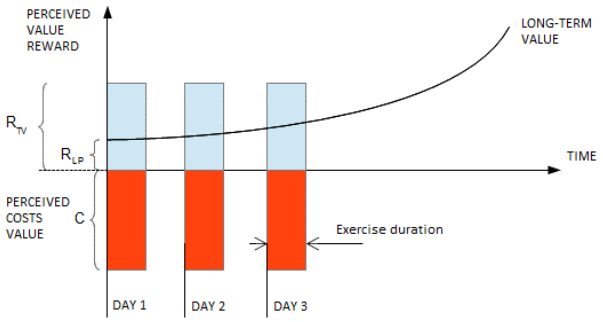

Figure 3: Temporal discounting, perceived value reward, cost and machine reward over time.

Doing physical exercises involves a considerable amount of energy and a sort of discomfort that becomes a cost in the amount of motivations needed to take a decision. The cost C counters the motivational effect of the reward. As it is shown in Figure 3, this cost is constant during the exercise and it is null after this one. Figure 3 shows that, at the beginning costs, are higher than the long term reward.

$$R_{LP} + C < 0 \tag{1}$$

This inequality can explain that if costs are higher than the perceived reward, the exercise would not be done.

The mechatronic system presented in Section 5.1 operates exactly at this stage, introducing a third contribute to Eq. (1). Having recognised the correct execution of the exercise (a set of push-ups in the presented case), the machine could allow the switching on of the television by means of a control system. Conversely, if the exercise had not been executed, the television will not be switched on. The possibility of watching television is to be considered a third reward, named *machine reward*. This last is indicated with R_{TV} and, for the sake of simplicity, it can be considered constant during the exercise execution (as a matter of fact R_{TV} could change over time). The machine reward increases the one related to the perfect physical condition. Finally, it is possible to conclude that someone would execute push-ups exercises only in the case in which Eq. (2) is verified.

$$R_{TV} + R_{LP} + C > 0 \tag{2}$$

Many studies with both human and non-human subjects have examined how individuals choose between rewards that differ in their delays and amounts [16].

Mazur in 1987 conducted a study on the shape of the delay of perceived value function by using an adjusting delay with pigeons [17]. On each choice trial, pigeons could choose between a red and a green key. A choice of the red key led to a fixed delay (e.g. 10 s), followed by a 2-s access to grain. A choice of the green key led to an adjusting delay, followed by a 6-s access to grain. The duration of the adjusting delay was increased or decreased many times, depending on the pigeon's choices, so as to estimate an *indifference point*, a delay at which the two alternatives were chosen equally often. For instance, when the standard delay was 10 s, the mean adjusting delay at the indifference point was about 30 s, suggesting that 2 s of grain after a 10-s delay was about equally with respect to 6 s access to grain after a 30-s delay. The standard delays were varied between 0 and 20 s and an indifference point was found for each condition. These points were then plotted on a graph with the standard delay on the *x* axis and the adjusting one on the *y* axis. The results for each pigeon were found to be well described by linear functions with slopes greater than 1 and *y* intercepts greater than 0. The value that the pigeons assign to the food-reward, indicated with v_r, decrease as the delay *D* increases. This delay was modeled as the following hyperbolic function:

$$v_r = \frac{V}{(1 + kD)} \tag{3}$$

V is the value of the reward without delay and *k* is a constant that takes into account how fast v_r decreases with increases in *D*. Mazur assumed that at an indifference point, the values of the two rewards are equal:

$$v_s = v_a \tag{4}$$

The subscripts *s* and *a* refer to the standard and adjusting alternatives, respectively. It can be easily obtained that:

$$\frac{V_s}{(1 + kD_s)} = \frac{V_a}{(1 + kD_a)} \tag{5}$$

Solving Eq. (5) for D_a, the following function can be found:

$$D_a = \frac{V_a - V_s}{V_s k} + \frac{V_a}{V_s} D_s \tag{6}$$

This result represent the equation of a straight line and it indicates that the hyperbolic function, used to describe the pigeon's behavior, is correct. From these results it is easy to understand that pigeons are not forward-thinking in their choices: in fact, they prefer to eat immediately few grain than to wait for a greater amount of food. So, we can affirm that the grain-reward for pigeons is subjected to a temporal discount.

Other mathematical models for temporal discount can be found in literature [17]. For example, the value-reward decay function can be described as an exponential:

$$v_r = Ve^{-kD} \tag{7}$$

where *e* is the base of the natural logarithm, or as a simple reciprocal function:

$$v_r = V / kD \tag{8}$$

4 CLASSIFICATION OF ANTI-HEDONISTIC MACHINES

In this Section a possible classification of different types of Anti-Hedonistic Machines, which induce or drive away someone to do an action, is proposed.
AHMs can operate in a large variety of modalities, introducing a reward (or a deterrent) which could persuade someone from misbehaving. In Figure 4, a classification (non-exhaustive) of these machines is proposed.

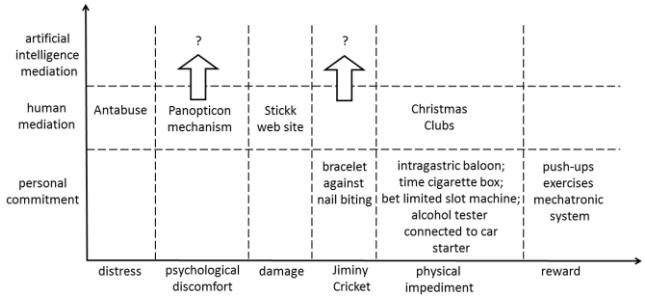

Figure 4: Classification matrix of Anti-Hedonistic Machines.

The matrix columns indicate the manner in which AHMs operate: from a motivational reward to an inhibitory high cost, such as psychological discomfort or distress. The rows show the different ways in which an AHM could be implemented: autonomously, with human mediating, up to an artificial intelligence (AI) support. To this regard, AI agents, such as chat-bots or artificial personal assistants, could play a significant role in preventing undesired behaviours.
The push-ups exercise mechatronic system, integrated with television control, introduces a reward and does not need an external human mediator to operate. It is positioned in the right-bottom side of the matrix.
A machine for physical exercises could also be integrated with a software able to modify the present body shape of the user, virtually showing the benefit of a long term exercise training on his body [18]. This is a sort of virtual reward.
A second class of AHMs is based on the concept of physical impediment. In this category, intra-gastric balloons, timed cigarette boxes, bet-limited slot machines and alcohol testers connected to the car starter can all be included. The intra-gastric balloon, a technology developed to treat obesity, has already been introduced in Section 2. The timed cigarette box is an artefact that consists in a small box which prevents people from immoderately smoking, providing their contents only after a pre-set timing. Obviously, it is not possible to damage this kind of machine without introducing another cost. Bet-limited slot machines are a deterrent for pathological gambling, by pre-setting the maximum upper game limit above which it is no more possible to bet. Nowadays, in several countries such as Australia, Canada and Norway, a law that imposes a pre-setting function in slot machines is in force [19].
Another impediment-based mechanical system is an alcohol-tester connected to the car starter: before turning on the engine it is necessary to blow in a pipe and, if the detected alcohol level is higher than allowed, the car does not start [20].
In the same column, in the *human mediation* row, it is possible to find an example of bank transfer which can be considered as an AHM. *Christmas Clubs* were deposit funds very popular in the USA during the Great Depression in the 1930s. Every week a tiny amount of money was transferred on the fund and the total amount would be given back only during Christmas time [21]. In this case the precommitment could be applied thanks to the mediation of third parts (i.e. the bank employees). For this reason this artefact takes place in the second row of the AHMs classification matrix.
On the left column *Jiminy Cricket* concept based machines could be found. The cricket acted as Pinocchio's conscience [22]; in the same manner, machines belonging to this category are *reminders* for people using them. An example is given by special non-removable bracelets which prevent people from nail biting [23]. Other examples are given by sensors that identify when the nails are coming close to the mouth of the subject and that trigger an auditory alarm [24]. Nowadays, several smartphone or wearable devices' applications act as reminders, by recalling the user to positive habits or routines (i.e. remember to play sport, walk for at least 10.000 steps every day, sleep at least 7 hours, eat healthy, drink enough water every day, do not stay too long in front of the computer screen consecutively and so on) by means of visual, auditory or even haptic stimulations.
Moving to the left in the matrix, AHMs developed for strong and persuasive actions can be found. Because of the potentially dangerous impact of the machine without the mediation of specialist staff, the *personal commitment* box in this column is empty. In the website *www.stickk.com* it is possible to publish a personal commitment, but, at the same time, the user has to transfer to the website an amount of money. The website becomes the temporary owner of the money and the user personal commitment is communicated to a group of people that has to monitor the achievement of the intention. The amount of money would not be given back if the goal has not been reached [25]. For this reason the personal commitment artefacts belong to the category that operates by introducing a deterrent or a damage, which in this case is the possible loss of the transferred money.
Psychological discomfort-based machines operate by means of the *panopticon* mechanism [26]. The term was thought up by the English philosopher and jurist Jeremy Bentham in XVIII century and it means "to monitor everything" (from: *opticon*, to monitor and *pan*, everything). It refers to the ethical and correct behaviour of someone who knows to be under control. Bentham idealized a new concept of jail in which the cells are arranged in a radial manner so as all the prisoners of the institution could be observed by a single watchman without the inmates being able to tell whether or not they are being watched (an example of penitentiary inspired by this concept is reported in Figure 6) [27].

Although it is physically impossible for the single watchman to observe all cells at once, the fact that the prisoners cannot know when they are being watched means that all inmates must act as though they are watched at all times, effectively controlling their own behaviour constantly. The term *panopticon* also refers to Argus Panoptes, a many-eyed giant in Greek mythology, who was known, for this reason, to be a very effective watchman [28].

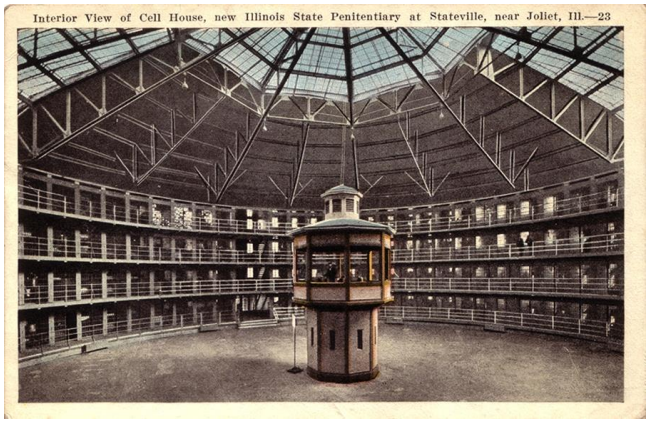

Figure 6: Interior view of Illinois State Penitentiary, inspired by the concept of *panopticon*.

An example of emerging technologies based on the *precommitment* concept is given by *Lifelogging*, which includes all wearable sensors enabled to collect visual and biometric information about a person. In this context, Doherty et al. [29] developed a software capable of classifying particular features of the life-style of a person in an automatic manner. The method is based on semantic image segmentation and it has been applied to a group of 33 people for a period of 3,5 years with interesting results. This kind of systems can easily be integrated with social networks and make data available to the entire community. It can be easily understood that these artefacts are able to modify the subject's habits with respect to the information shared online with the other users.

On the far left column of the matrix, distress-based machines are located. Disulfiram, better known as Antabuse, is a medicine used in the treatment of chronic alcoholism by producing the effects of a "hangover" if alcohol is consumed. It works as a real AHM which uses a chemical deterrent to prevent people from drinking alcohol. Human mediating, as the doctor who prescribes it, is strictly required.

Another class of Anti-Hedonistic Machines is given by the *Habit-Reversal Artefacts* (HRA) [30]. The term *Habit Reversal Training* (HRT) addresses to all the techniques that aspire to eliminate a bad or unpleasant habit (e.g. tics, trichotillomania, nail biting, thumb sucking, skin picking, temporomandibular disorder and stuttering [31] [32]) by replacing it with a competing response that is more acceptable or socially virtuous. This procedure is not based on a real commitment but on the mind capability to accustom habits. HRT consists of five components [30]: awareness training, competing response training, contingency management, relaxation training and generalization training. Research on the efficacy of HRT for the aforementioned behavioural disorders has produced consistent and large effects [32]. An interesting example of *Habit-Reversal Artefacts* can be given by the electronic cigarette [33]. In this case the pleasure given by the smoking is implemented by a mechanism that provides a semblance of the real cigarette sensation, by maintaining the gestures and limiting the noxious effects.

5 EXAMPLES

In the following, some examples of AHMs are described.

5.1 PUSH-UPS EXERCISES MECHATRONIC SYSTEM

In this Section a push-ups exercise mechatronic system is presented. As described in Section 2, this machine induces the user into doing push-ups, by introducing a reward, indicated with R_{TV} in Eq. (2): the possibility of watching television if the exercises have been correctly done; or a deterrent: the impossibility of switching on the lights, the television or powering the fridge. In Figure 7 an operating scheme of this AHM is shown.

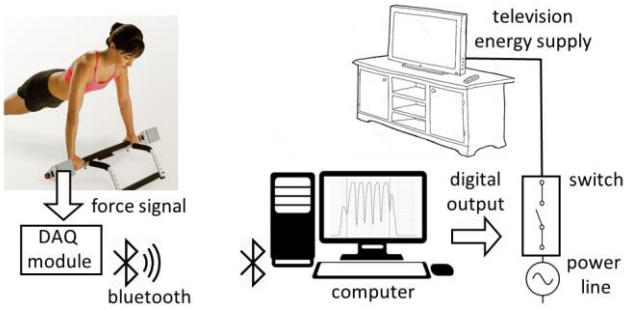

Figure 7: Push-ups exercises AHM operating scheme.

The mechatronic prototype is composed by a gym push-ups tool, on which a measurement set-up is installed, a data acquisition system and a control device which activates the television energy supply. Data from fitness exercises are provided by two VISHAY BAK 200 strain gauges mounted on the metal bar of the tool, which are able to detect the bar deformation during the exercises.

The bar displacement is traduced into a voltage signal by means of strain-gauges, which are integrated in a full Wheatstone bridge. This analogue signal is filtered and converted into a digital one in an EMANT 380 DAQ module and it is sent to a computer by means of a Bluetooth connection. The signal is analysed by a control software implemented in Python™ environment and based on a simple machine learning algorithm, which compares each training session with a reference one. This last has to be executed in a proper manner in the initial phase, when the user is determined and his willpower still strong.

After the signal analysis, the control system returns, as output, a Boolean variable which closes or opens a switch depending on the outcome of the strain-gauges analysis. If the exercises are correctly executed, the switch will be closed and the television could be switched on. If not, the digital output will consist in a *false* constant and the power line will be interrupted.
Furthermore, the system is programmed in such a way that it requires a daily amount of exercises. In Figure 8 a picture of the push-ups tool is shown. On the left-back side the DAQ module can be seen and, on the right side, the control system box with the switch of the 220 Volt electric current, is reported. Obviously, the mechanical system has been developed in such a way to prevent the user from easily bypassing the switch.

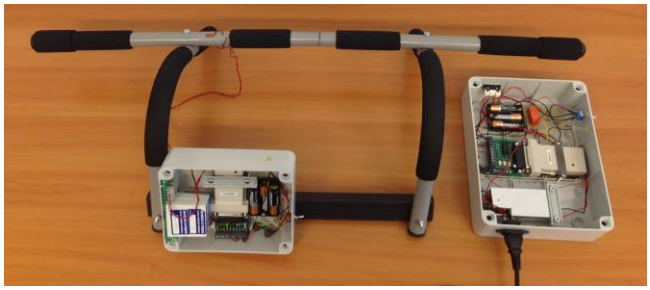

Figure 8: Push-ups exercises AHM.

5.2 ANTI-HEDONISTIC MACHINES FOR OBESITY FIGHTING

Worldwide obesity has more than doubled since 1980. In 2014, more than 1.9 billion adults, 18 years and older, were overweight. Of these over 600 million were obese. 39% of adults aged 18 years and over were overweight in 2014, and 13% were obese. Moreover, most of the world's population live in countries where overweight and obesity kills more people than underweight [34].
Nowadays, obesity fighting could be one of the possible large-scale applications of Anti-Hedonistic Machines. A tapis roulant and a weight scale, in combination with a control and monitor unit could play the role of an AHM for treating obese people. In Figure 9 an overview of the operating system of such system can be seen. In particular, the tapis roulant have to be connected to sensors that have to assess presence and activity of the subject (bottom-left of Figure 9). Moreover, a constant monitor on the weight of the user is required and no chances of bypassing it have to be present. For this reason, systems like face or fingerprint recognition have to be adopted (upper-left side of Figure 9).

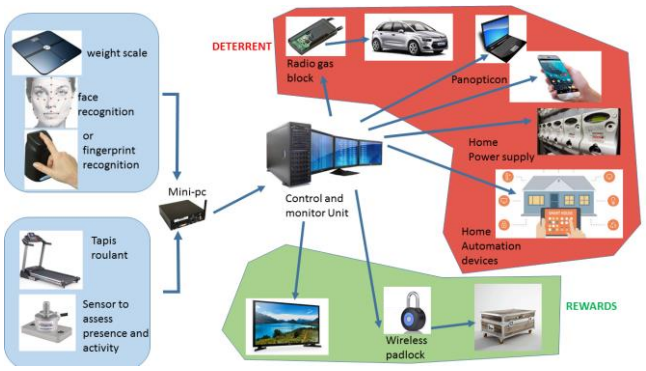

Figure 9: Overview on the operating principles of AHM for obesity fighting.

Furthermore, in order to guarantee the correct functionality of the anti-hedonistic system (a daily amount of time spent running on the tapis roulant and the monitoring of the user weight), a deterrent has to be introduced (right side of Figure 9). The deterrent, or cost, can be a physical impediment (e.g. the block of the car starter or the home power supply), a social one (e.g. to lose a working day in the case of unavailability of the car), or even psychological (e.g. through the *panopticon* mechanism all the user's friends or family members could be kept up to date on the weight trend).
Finally, the Anti-Hedonistic Machine for obesity fighting could also require a reward to the user, such as the aforementioned possibility of watching television if the exercises are correctly done (bottom-right side of Figure 9).
Anti-Hedonistic Machines might also introduce risks with respect to the people that are adopting them. These risks could be physical, social or psychological. The first category comprehends all the cases in which the user, for example for emergency reasons, have to access to a resource that is precluded by the AHM. Physical risks could be domestics (e.g. someone could be blocked inside the elevator), but also related to the automobile (e.g. a non-correct functionality of the starter). Social and psychological risks are those related to the introduction of the *panopticon* mechanism: the subject involved in the treatment might be victim of derision, mockery and bullying. With regard to this it is to underline the importance of the people that have to monitor the subject involved in the anti-hedonistic machine treatment.
The privacy is also to be taken into account when an external monitoring is introduced. In fact, the loss of information about the subject out of the "panopticon circle" could be really damaging.
The last risk connected to the use of Anti-Hedonistic Machines is related to the addictiveness of the user with respect to the machine: a good habit introduced with the system could be lost when the treatment is interrupted.

6 CONCLUSIONS

In this paper the concept of Anti-Hedonistic Machines (or artefacts) interacting with humans has been presented. This novel concept has been firstly explained through the point of view of the mismatch theory. Then, the operating principles of these technologies have been provided with particular attention to the concepts of *precommitment*, *temporal discounting*, *cost* and *machine reward*. Different examples have been discussed and a possible classification (non-exhaustive) has been proposed. In this context, the manners in which Anti-Hedonistic artefacts operate and the ways in which they could be implemented have been exposed. Finally, a mechatronic system for prompting a subject to do push-ups exercises has been described and a possible application of AHMs to treat obesity has been discussed. In the future, Anti-Hedonistic Machines could play an important role in society and their presence will certainly grow in terms of numbers and applications.

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