PeTeR – Personal Trainer Robot

Exploring the possibilities of a personal trainer robot

MIX301 Media Technology: Theory and Development

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Fall 2020

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1.0 Introduction

Personal assistant technologies are playing a larger role in society today. The majority of people have used a personal assistant like Siri or Alexa on their phone. Assistant robots are also emerging and getting more popular, like robot lawn mowers and vacuum cleaners. Let's not forget about the self-driving cars that people use as their personal assistant drivers. These are all technologies meant to make life a little easier. The possibilities for personal assistant robots are endless, and we have only started to explore this world.

Industries should be aware of these technological inventions designed to ease our life. In the future the gym industry and the personal trainers may face competition or help from new technology. In this essay I am presenting the prototype for PeTeR the personal trainer robot. PeTeR is not only a robot, but he is also connected to the gym, turning the gym into a "Smart Gym". The conceptual idea of PeTeR will end up as a cybernetic machine with autonomous and independent goals. In the future he will use computer vision, artificial intelligence, computer hearing and his sensors to become a personal trainer robot.

The goal throughout this essay is to explore the possibilities and limitations of introducing a personal trainer robot for younger adults at gyms. I will do this by firstly exploring some background information about the human-robot interaction field, as well as looking into a similar technology in the field. Secondly, I present the methods provocative prototyping and research trough design as my prototyping methods for PeTeR. The ethical aspect of the prototype is of great importance and I will look into how some people might find this prototype provocative. Thereafter, I show the first prototype design iteration and explain the technology used to achieve the prototype. Lastly, I explore the future prototype for PeTeR by creating a persona followed by scenarios. I use cybernetics to shed light on the concept's full potential, and finally, I take Hubert Dreyfus`s critique of AI into consolidation.

2.0 Background

What can be considered a robot? People may answer this very differently in regard to how they define a robot. Originally, the word robot comes from Czechoslovakian word "robota" and stands for "forced labor". One can define a robot as "a machine capable of carrying out a complex series of actions automatically, especially one programmable by a computer" (robot, 2020).

2.1 Human-Robot Interaction

The human-robot interaction (HRI) field is known as a "study dedicated to understanding, designing, and evaluating robotic systems for use by or with humans" (Kanda, 2012). It is possible to categorize interaction into remote- and proximate interaction. The interaction between PeTeR and its users is known as proximate interaction. This is because both PeTeR and the human are co-located, and they interact physically in the same room or environment. We can also distinguish between applications that require physical manipulation, mobility or social interaction (Kanda, 2012). For PeTeR one can argue that he requires all of the actions mentioned above. PeTeR is a mobile robot in the way that he moves around the gym like a robot assistant. He uses physical manipulations in the way that he has sensors in the workout apparatus and can modify these. PeTeR is social because he interacts with the user as the users' companion and workout partner.

2.2 Robotics in Health and Fitness

At the time of writing, the words "online fitness coach" will give you over 533 million search hits. Online fitness coaches are usually real people giving out their personal trainer services over the internet. Other times they are selling premade programs sold after the persons needs and goals. In other words, training services are highly requested.

Today, when people talk about personal assistant robots, we often think about the autonomous vacuum cleaner or the assistant home devises like Google Home. But in the works, there are many more advanced robots, able to do way more impressive tasks than cleaning the floors or answering a question.

Pepper was made to help coach gym goers, based on the persons heart rate, speed, personality type, mood and fitness level (Snead, 2019). This robot was specifically made to coach runners though exercise programs on the treadmill. While the person was doing the workout Pepper would tell jokes, show sympathy and change the eye color to express emotion. Pepper was trained by a human personal trainer in order to know how to encourage and motivate the runner. A field trial was done with 10 people between the age of 20 and 60, who attended three times per week at the gym for three months.

The intention of the field trial was to see if they could "transfer the intelligence of our fitness instructor, an expert with the know-how to get the best out of clients, into a robot so it could become an effective personal coach" (Snead, 2019).

The result of this field trial was surprisingly positive. The participants where energized by Pepper and pushed themselves harder than they usually do. Another surprising find from the trial was that as the time went on the participants started to treat Pepper as their companion and the personal trainer saw the robot as a colleague. The senior researcher at Bristol Robotics Laboratory Dr Severin Lemaignan stated that "Our work shows a robot could be really useful in the gym, especially for people who would perhaps feel embarrassed with a human personal trainer" (Snead, 2019). This study is highly relevant for PeTeR`s development, and it is interesting to see a similar product being tested in a real workout scenario.

3.0 Provocative Prototyping

There are several prototyping approaches, and some newer ones differentiate from the more traditional. One of these design approaches uses provocations deliberately to challenge established perceptions. This is known as provocative design and aims to "challenge existing norms and attitudes, provoke discussion, and provide means for a constructive critique about the design itself, its impact, as well as the broader assumptions that characterize an area of interest" (Raptis et al., 2017, p.29.)

We can categorize provocation into aesthetic, functional and conceptual provocation. Aesthetic provocation is related to the visual look and materials used, while the functional provocation is about the way it works functionally. The conceptual provocation is referring to the idea that it tries to challenge or critique (Raptis et al., 2017, p.29-30.) I would categorize the PeTeR prototype to be a conceptual provocation, because the idea itself tries to challenge the gym industry and PT jobs today. The impact a system like PeTeR may have on the gym industry and the users, may be disruptive and provocative for some people. There are several reasons why people might find PeTeR provoking. Firstly, PeTeR challenges the idea of a personal trainer, which again challenges the human personal trainers themselves. The human personal trainer might see this as a threat to their job and career and this is provoking in itself. Secondly, the gym industry today is the same as it has been for years. The workout equipment

is still mechanical metal weights and there has not been much new technology introduced to this industry. Making PeTeR the robot a part of the gym, turning the gym into a “smart gym” will definitely change the way people work out. These are some aspects of the PeTeR prototype I believe people will find provoking.

3.1 Research Through Design

Users usually cannot tell you what they want, but when you show them something, they can easily tell you what they do not want (Sharp et al., 2019, p.422). Creating a prototype can be a helpful tool to illustrate an idea and to examine whether it is sustainable or not. When describing the prototype PeTeR, I will use the design process itself to give some reflections and to better understand the area of interest. This method of prototyping is also known as research through design, because one uses the design process to discover possibilities in a design space (Raptis et al., 2017, p.29).

It is important to understand that a prototype is fundamentally different from the finished product. The prototype of a project can be seen as means and tools for design and not the ultimate target for design. This means that the mindset for the designer is different when creating a prototype, then when the designer is making the final design (Lim et al, p. 14.) While creating the prototype for PeTeR we knew it would be different from what we imagined the finished product to be, due to the size of the project. Because of this the prototype for PeTeR is going to be created I several design iterations. I will start by presenting the first design iteration of PeTeR, then I will show the future plan for the next iterations.

3.2 PeTeR - Design Iteration 1

One can differentiate between low- and high-fidelity prototyping. A low-fidelity prototype does not look like the finished product and it lacks the actual functionality. A high-fidelity prototype looks more like a finished product and provides more functionality than a low-fidelity prototype (Sharp et al., 2019, p.426-429.) The prototype created for PeTeR is more of a high-fidelity prototype than a low, because the prototype shows some functionality and also resembles how the finished product will look like.

The goal for the first prototype iteration was to show some core functionality during the semester demonstration (figure 2). The demonstration of the prototype consisted of PeTeR greeting the participant and guiding the participant to the workout station. While following

the participant PeTeR entertained with a fun and motivating dialogue. At the workout station PeTeR gave the participant the task of doing three squats in front of the human pose estimation station. PeTeR then gave the participant some feedback from their quick workout. Lastly, he drove back to the entrance of the smart gym.

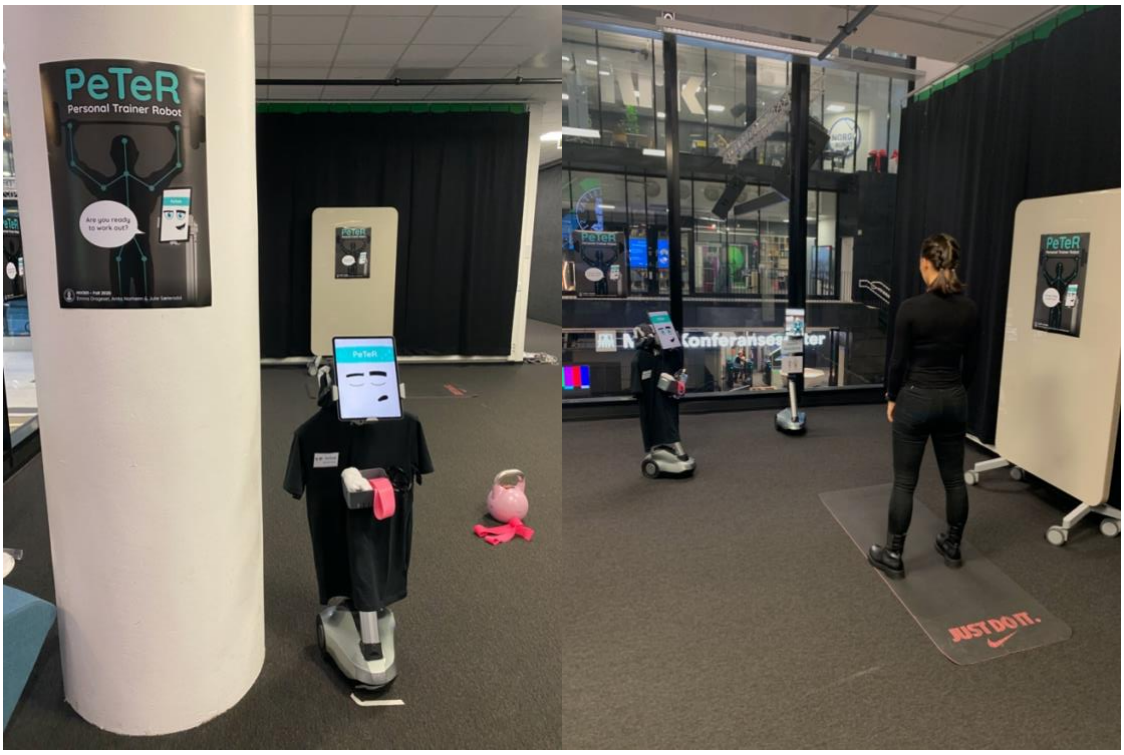

Figure 2: To the left, a picture of the starting position of the demo. To the right, the squatting station being used in the demo.

3.2.1 Technology

To create this initial prototype there were several technologies used to achieve the finished demonstration. In the following section I will go through the technology used in the live demo.

PadBot U2:

We used the PadBot U2 as the body of PeTeR the personal trainer robot. The PadBot U2 is a semi-autonomous body that has sensors and can be used for many different tasks. We used Android Studio to program some routes for this PadBot. For the demo we programmed the "workout route" and the "go home route". To activate the programmed code, we synced the code to an Android phone and used this to activate the two routes. In addition, we had an

extra PadBot U2 that was used for the “Squat Station” also known as the human pose estimation station.

Adobe XD:
In total we used two iPads at the demo, one for the “Squat Station” and one for PeTeR`s face. The iPad used for PeTeR`s face and voice was created in Adobe XD. Here we created a script that got activated by tapping the screen, PeTeR`s face also changed throughout the demo.

Human Pose Estimation:
Human pose estimation is a computer vision technique used with video or image to detect human joints. This technology makes it possible to locate human figures that can be used for various things. The human pose estimation algorithm we used in the demo was created by Google Creative Lab and TensorFlow, called PoseNet (Oved, 2018). This algorithm cannot identify who is in the image or video but simply locate where the person is and what position the person is in. The algorithm was used during the demo to show the users the human pose estimation of their position at one of the PadBots that we called the “Squat station”. The algorithm could be downloaded as a JavaScript file or used directly in the browser, as we did during the demo because it was more convenient for the iPad. One could choose between Single-Person Pose Estimation (SPPE) or Multi-Person Pose Estimation (MPPE) in the algorithm. We chose MPPE because when we used SPPE the pose estimation would be wrong if someone came in the frame of the screen, and by using MPPE the pose estimation would just register another human pose.

3.2.2 Wizard-of-Oz

The participants of the demonstration fully accepted that they were having an interaction with PeTeR the personal trainer robot. After the demo was done, we showed that the experience was partly Wizard-of-Oz based. Wizard-of-Oz is a technique used when creating prototypes and is “essentially a simulation of functionality that doesn’t exist yet in an interface application” (Lazar et al, 2017, p.293-294). This technique makes the user think that it is interacting with the interface or system, but in reality, the user is interacting with another human being that is providing the responses for the user. In our demonstration we showed that the user had to talk to the iPad and then touch the screen in order to make it respond with voice, face and movement. This was an illusion because by tapping the screen the script of PeTeR continued to the next one. We started the routes for the PadBot when an action was

made by the participant. Wizard-of-Oz method is usually used when the functionality has not been built due to expenses of the technology or when the technology does not exist yet. Even though this method is often used as a usability testing method, we are happy to use a method to see how the participants reacted on this type of technology.

3.3 PeTeR – Future Design Iterations

Personal trainers use their customers' bodily strengths and weaknesses to create a personalized workout plan. They give both physical and mental guidance as well as preventing injuries (Workable, u.å). The main goal for PeTeR is to be injury preventive through improving technique and position. After many future design iterations PeTeR will be able to do everything a human personal trainer can do, only much cheaper and better. To make this possible PeTeR will be connected to the gym using sensors in the workout apparatus and by using human pose estimation technology. This future version of PeTeR will reshape the entire gym industry by turning the gym into a "smart gym".

The desired target group for PeTeR are young adults that already go to the gym. I believe that this is the ideal target group because young adults tend to use more technology and are more open to trying new technology. In addition, it is easier to get the people that already go to the gym to use PeTeR. Furthermore, young adults tend to have lower economical capacity than other older established adults and a human personal trainer may be too expensive for them.

3.3.1 Persona

When creating a prototype, it can be useful to form personas in order to showcase a typical user of the product and to highlight the technological requirements. The personas are detailed descriptions of a typical user including their independent goals, behavior, environment and attitudes. An advantage of using personas is that it helps the designers of the prototype to make design decisions for the right users, as well as reminding them that real people will be using the prototype (Sharp et al., 2019, p.403-404.) Personas are not specific people, they are based on real users that have been involved in some data gathering. In this essay I will create one persona due to the reasons stated above. This persona will not be based on a set of user files, but it will be inspired by some people observed at the gym. I will also use the persona to illustrate how the prototype can be used by its intended user and create scenarios based on the persona. Figure 1 shows the persona of Sara the young adult.

Young Adult

Name: Sara Nilsen

Age: 22

Work: Fulltime student

Energetic

Perfectionist

Impatient

"I want a workout companion that can motivate and push me to workout"

Goals:

- To gain knowledge about how to workout
- To become stronger and to use more wights while training
- To feel supported and be reassured in her workout technique

Frustrations:

- Deciding what to workout each time
- Not knowing how much weight to use and how much she should be progressing
- Her damaged knee after playing football in her teens

Bio:

Sara is a busy fulltime student studying economics at the University of Oslo. She has a part time job as a waiter at the restaurant Olivia where she earns some extra money in addition to her student scholarship. Her hobbies include hanging out with friends, watching tv series and working out at SATS. She has some workout experience from playing football in her teens, but she is not that god at working out by herself. Sara is very concerned with living as economical as possible and she only uses her money on what she views as necessary. Sara would like a personal trainer to help her gain some strength and to help her with her workout technique.

Figure 1. Persona of Sara. Picture of woman. From «Shutterstock», by D. Drobot (https://www.shutterstock.com/nb/image-photo/image-happy-young-business-woman-posing-1215373642)

3.3.2 Scenario

A scenario is a great way to show and describe behavior with new potential technology. Scenarios are informal narrative descriptions of a story that allows for exploration and discussion of the user's needs and the context (Carroll, 2000, p. 41-42.) Using personas in conjunction with scenarios will complement each other and give a fuller picture of the activities with the technology. I will use the persona Sara from figure 1 to create a scenario using PeTeR the personal trainer robot.

Sara is tired after a long day at school, but she wants to go and work out to feel better. She has a membership at her local SATS gym, and she decides to go for a workout. As usual, Sara has not prepared any workout plans for today.

When she walks into her gym, the first thing that she sees is a robot approaching her. The robot politely introduces itself as PeTeR the personal trainer robot. PeTeR explains that he wants to make a personal workout plan for Sara and guide her through her workout as well. All this is included in her membership at SATS and it will not cost her anything extra. Sara finds this strange but exciting, and she is willing to give it a try considering there are no extra costs and in addition she does not have a workout plan herself.

Sara grabs the removable tablet from PeTeR's body to register user information about her age, height, weight, previous exercise experience, goals and so on. PeTeR processes her information and gives her a few different options for a personalized workout. Sara choses the strength workout with weights, because she does not have much experience using weights. She gives the tablet back to PeTeR and he guides her to the workout zone. Sara sees that a big portion of the gym has been transformed to "PeTeR's Smart Gym", including some of the workout apparatus. She sees that all the workout apparatus has turned electronical with screens to control and adjust the weight instead of the mechanical steel weights.

Throughout the workout, PeTeR gives her feedback through her headphones about what to do and how to do it. This feedback is based on the sensors, pose estimation and her personal information. Sara uses a pulse watch, and PeTeR is taking this information into consideration. Because Sara has little experience with weight training, she finds it comforting when PeTeR gives her the feedback about the information she lacks. Sara is doing some exercises in the updated electronic squat machine and she thinks the weight is too heavy. PeTeR notices this

automatically trough his sensors and changes the weight to a lighter one, making sure that Sara does not get any injuries during her workout.

At the end of the workout PeTeR logged all of Sara's progress and information about how many repetitions and how much weight was used. Sara receives a message on her phone to download the PeTeR app in order to get all the information about her workout. The next day Sara gets a notification from the app reminding her to workout in order to reach her goals.

This scenario illustrates the concept and long-term goal for PeTeR and shows the big potential of a personal trainer robot. Someday, after many design iterations it may have evolved into this new innovative concept, reshaping the workout experience in the future.

4.0 Cybernetics

The word cybernetics originate from the Greek "kubernetes" which means "steersman" (Wiener, 1950, p. 15). During the 1940s the scientific field of cybernetics studied complex systems in both animals and machines (Petrick, 2019, p.2). A cyberneticist studies the control and communication in systems that work autonomously with independent goals.

There are several people that are central to the history of robotics and cybernetics. The American mathematician and philosopher Norbert Wiener is often referred to as the originator of cybernetics. He has written several books, the book *Cybernetics; Control and Communication in the Animal and the Machine* was especially popular in the scientific community when it was released in 1948 (Britannica, 2020). It was in this book the word "cybernetics" was first introduced publicly when referring to individual mechanisms.

Another well-known scientist in robotics and cybernetics is Rodney Brooks. In his book *Flesh and Machines. How Robots Will Change Us* he wrote that cybernetic machines are "autonomous in that they achieve their goals independently of humans. Humans need not to engage in a moment-to-moment control of their actions" (Brooks, 2002, p.10).

4.1 Black Box

Elizabeth Petrick's article *Building the Black Box: Cyberneticians and Complex Systems* she explores the term black boxing into detail. Here she states that cyberneticians define black

box as "a system where only the inputs and outputs are known, with the inner workings unknown or unknowable". She explained that black boxing was a tool used to break down systems that where too large to understand in other ways. Through understanding the inputs and outputs of the system one could simplify and understand originally complicated systems (Petrick, 2019, p.2).

4.2 Sensors, Actuators and Feedback Loops

In his book *The Human Use of Human Beings – Cybernetics and Society* released in 1950 Wiener points to cybernetics three general features: actuators, sensors and feedback loops. Firstly, actuators work as the moving organs of the robot, like for example moving legs or arms used to affect the world around it. Then we have the sensors that can be many different things used for input. He used examples like thermometers and photoelectronic cells to record the performance or non-performance of their own tasks. This brings us to the last feature, known as feedback loops (Wiener, 1950, p. 33). The robot needs to be able to adjust its own future conduct, according to its past performance. In other words, the feedback loop is a process where the outputs of the system are circled and used as input.

In the first iteration of PeTeR`s prototype he used both sensors and actuators during the demonstration. He had several sensors taking in input from the sounding word. Firstly, the robotic body had sensors in the front and in the back of the robot. These sensors would make sure that if someone or something was in PeTeR`s way, he would stop. Another sensor used was the tapping sensor on the iPad, making the script of PeTeR go to the next step. The last sensor used was the human pose estimation on the second iPad, that located the human joints through visual sensors. The actuators used in the prototype was the wheals on the robot, that made it possible for PeTeR to guide the participants.

The future concept of PeTeR would be much more complicated that the initial prototype. I will now use the persona Sara presented earlier in the essay to show how the future actuators, sensors and feedback loops can be used in the concept. As I motioned earlier in the essay Sara walks into an area of the gym called "PeTeR`s Smart Gym". Today gyms like SATS already have dedicated areas for their PT`s, where the equipment is only used by PT`s with clients. Similarly, to this, PeTeR will have a dedicated sone in the gym where all the workout apparatus is connected to PeTeR. This would mean that the apparatus would have to be redone or modified into electrical or hydraulic apparatus so that PeTeR would be able to

modify the weight of the apparatus. PeTeR has sensors in all the workout apparatus in the gym as well as the local sensors on the body of the robot itself. This would also make the apparatus a part of the actuators of PeTeR, making it possible for him to change and know how much wight is being used. The future PeTeR would also use feedback loops in order to better himself, and to be more like a real human PT.

In the scenario this feature would have an important role and will make PeTeR even better. The next time Sara and PeTeR works out together, Sara wants to better her weight limit. She tells PeTeR at the beginning of the workout that she wants to use heavier weights this time. PeTeR takes this information into consideration, but he explains that because of her knee injury he needs to see how much weight it is sustainable to add without affecting her knee injury further. He will then use the sensors in the apparatus to "feel" how much weight Sara can handle before her technique is compromised which PeTeR can check using the human pose estimation technology. This intelligent modification of the workout apparatus would make PeTeR a part of the gym, making it into a smart gym.

5.0 Hubert Dreyfus Critique of Artificial Intelligence

The philosopher and professor Hubert Dreyfus is well known for his critique about artificial intelligence. While Dreyfus was working as an assistant professor at Massachusetts Institute of Technology (MIT), his students where telling him how his philosophical theories about knowledge and perception were outdated due to computers. This led Dreyfus to publish the article *Alchemy and Artificial Intelligence* in 1964. This was the first detailed critique of artificial intelligence (AI). Later on, he also published two books *What Computers Can`t Do* in 1972, and later on in 1992 he published the book *What Computers Still Can`t Do* (Brey, 2001, p. 1-2). These two books got both a lot of positive feedback but also some critique form computer scientists. Dreyfus has been influenced by philosophers like Heidegger, Merleau-Ponty and Wittgenstein. He uses their arguments regularly in his critique of symbolic AI.

Dreyfus made a skill acquisition model with five different stages for skill acquisition. The five stages go from lowest skill acquisition on to the highest, starting with Novice, Advanced Beginner, Competent, Proficient and Expert (Brey, 2001, p. 10-12). One can argue that since human personal trainer are "experts" in their field this is the level PeTeR should be at in order to be a robot personal trainer.

Dreyfus criticizes what he refers to as the four primary assumptions of AI. The four assumptions are the biological-, psychological-, epistemological- and ontological assumption. The biological assumption is the assumption about how the brain functioning involves implementation of a symbol processing system. The second assumption in the AI community is the psychological assumption. Where they believe that the mind can be seen as a device operating on bits of information according to formal rules. The most criticized by Dreyfus is the epistemological assumption, that states that all knowledge is formalizable. Lastly, the ontological assumption is about how independent facts can be represented by independent symbols (Brey, 2001, p. 4-6). One of Dreyfus`s main critiques are that intelligence is situated and embodied. He argues that "If intelligence is indeed situated and embodied, then it does not appear possible for digital computers to possess the broad scope of human intelligence, for they are not embodied and do not have a full human world at their disposal".

Hubert Dreyfus`s critique on AI is relevant for PeTeR because in order to become a robot personal trainer PeTeR must gain some sort of intelligence. What kind of intelligence can PeTeR have? If he is meant to substitute or help human personal trainers, PeTeR need to be able to communicate and understand the users. It is also interesting to reflect on whether PeTeR will be able to reach the same level of intelligence as a human personal trainer. We have to take into account that personal trainers have an education. They learn about the human body and how to train someone in regard to how the human body works. If Dreyfus was going to answer this question, he would say that a robot personal trainer would never reach the level of intelligence as a human personal trainer. However, we have to take into account that Dreyfus`s arguments were made some time ago. Technology is moving in a fast pace and there is a big chance that in the near future the technology PeTeR needs will be possible to create and use. If this is the case, that robots can reach some kind of intelligence, PeTeR and many other projects will be able to create.

The psychological assumption is also interesting when considering how PeTeR will gain a personal relationship to his users. Human personal trainers do not only tell you how to work out, they can also be a support both mentally and physically. The physical aspect of support can be regulated when the apparatus is a part of PeTeR, but the psychological aspect is more complicated. Clients of the PT gain a lot of trust in in their PT and some PT goes even further

than being a support when working out. Many PT`s are more like life coaches and will help their clients with life choices in general. This can be everything from what to eat to bigger and more important questions. This is an aspect of PeTeR where the technology today may have difficulties reproducing this personal aspect of being a personal trainer.

Lastly, one of the advantages PeTeR has over real human personal trainers is the ability to process huge quantities of information. Computers are great information processing machines. This means that PeTeR can proses all the user information and the information from the sensors quickly. Information about the user's damages, weight, fat percentage, pulse, health journal and so on can help PeTeR be a better personal trainer. These types of tasks can be quite energy and time consuming for humans and is more suited for computers.

6.0 Conclusion

In this academic essay the personal trainer robot PeTeR was presented with several prototyping iterations. By using theories about human-robot interaction, provocative prototyping, cybernetics and artificial intelligence I have shed light on some positive and negative aspects that comes with PeTeR. By looking at other similar work in the field I observed that a personal trainer robot can affect the user's motivation in a positive way. This also showed that PeTeR does not necessarily need to be a threat to PT jobs, but on the contrary; he can be used as a support.

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