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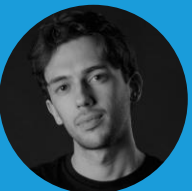Automation and Control
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SEI AI

HOW AI-DRIVEN HUMANOID ROBOTS CAN CREATE NEW BUSINESS OPPORTUNITIES ENHANCING THE GYM EXPERIENCE

Executive summary

The challenge presented in this work was to identify new business applications for a humanoid robot exploiting its empathic capabilities. More specifically, the humanoid robot Pepper was provided by our industry partner, Sprint Reply. According to the vast diffusion of technological devices for the support of people's physical wellbeing, our team decided to make Pepper a personal trainer, capable of following a user during a free body training session. Counting repetitions, correcting errors or showing past performance are just some of the features implemented. As opposed to exercises with machines, with free-body ones the athlete has total freedom of movement, increasing the probability of mistakes. As a consequence, this could reduce the benefits of the workout and also create physical injuries. Our solution enables Pepper with advanced AI-based algorithms to monitor the execution of the user's exercises through human body pose evaluation. Providing a non-human solution in the role of personal trainer helps to lower costs for customers and generates a profit opportunity for gyms that decide to supply it. Pepper would be a scenic and attractive element as well as helping personal trainers to manage the numerous members. After an initial investment, our solution will bring a profit to the gym and gym-goers could fight the lack of consistency in their workouts maintaining a high level of involvement and motivation thanks to a more continuous relationship. Our solution represents a strong technology push in fitness, which is characterized by strong technological growth in this last period.

Key Words

Humanoid-Robots, Technology-for-fitness, computer-vision, body-pose-estimation

Figure 1: AI SEI team
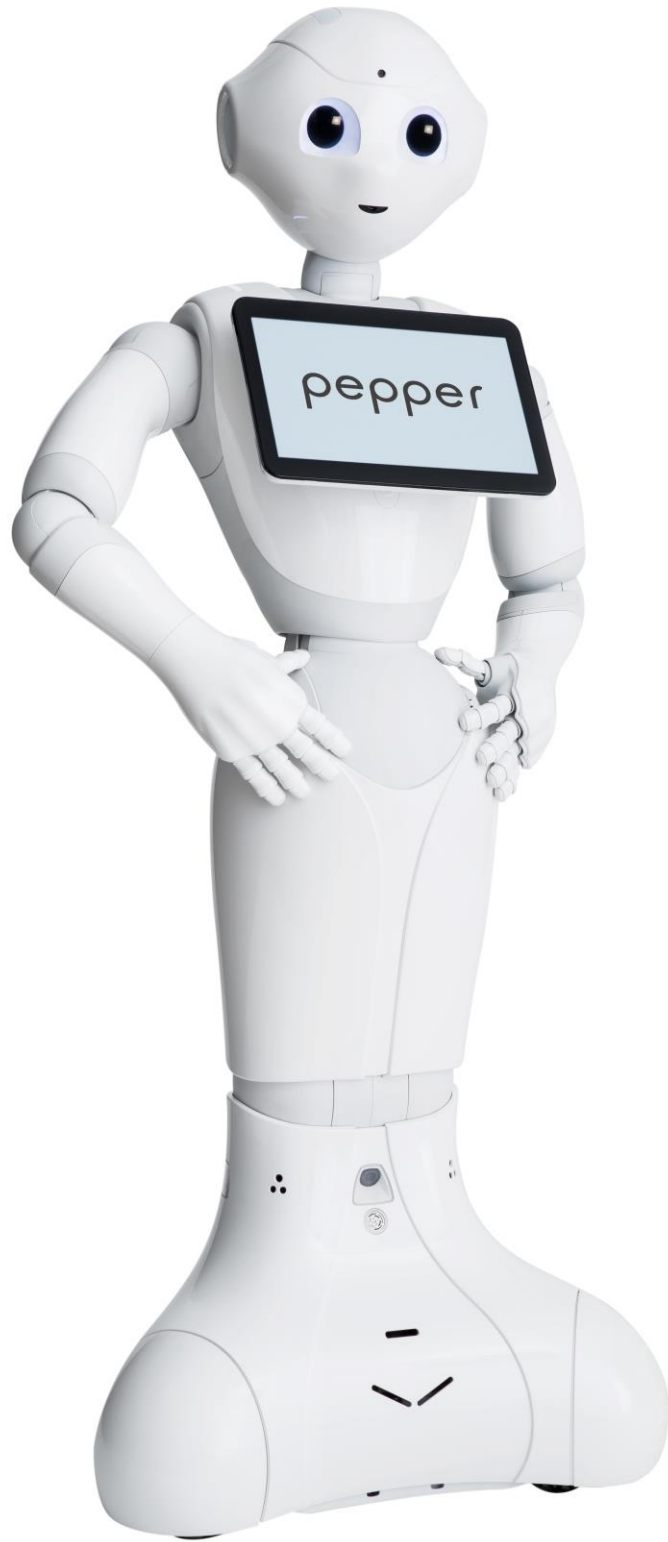
Project description written by the Principal Academic Tutor

The challenge the AI team is asked to address is finding a new business application for a humanoid robot by exploiting and possibly improving its empathic capabilities. Nowadays, humanoid robots have taken an important role in the automation of the processes in many industries, especially in service fields like retailing, airport assistance, education, healthcare, and many others. This challenge aimed to find new life within these areas or to discover another one where such technology could provide benefits. After an accurate analysis, Team AI focused on the fitness field, since the impact of humanoid robots and artificial intelligence could be significant in addressing some emerging needs in the modern gym concept: constant professional monitoring, customization of the gym experience, and cost accessibility are only three of them.

The starting point of the project is Pepper, the most known and spread humanoid robot in the world. To achieve the objectives set, the team designed and prototyped the first existing "personal trainer" robot, able to guide the athlete during his training sessions, monitor him, and give him tailored feedback on the performance. Moreover, integrated and automatic support provides personalized suggestions to improve the correctness of the execution.

During the development of the MVP, the team worked on the android application, that provides the user-machine interface and the general business logic of the system as well as the general robot controls, and on specialized deep learning algorithms, that enables the robot to the user identification step and the action correctness evaluation based on human body pose estimation. In parallel with these activities, attention was also placed on the definition of the user experience and in general of the design of the final product. All the choices followed a user-driven design thinking approach, in which users' needs were put first in the evaluation of concepts through in-depth research and constant feedback through interviews.

The same process also led them to the definition of a business model completely compatible with the current market and which embed the needs of the target segment identified.

Team description by skill

Andrea Megaro and Alberto Catalano were the most committed from the algorithmic point of view and the ideation of the mathematical solution. They took care of the high-level theoretical structure and the python implementation of the exercise correctness analysis. Giuseppe Pastore and Innocenzo Lagonigro worked on the programming of the robot control software and the development of the android application used as an interface. Lapo Peruzzi took care of the user experience of the service provided by our solution, as well as of the application's UI design. Daniele Gusmini was responsible for the assembly of the various software and hardware components, of the deployment of the python code on specialized hardware as well as of the facial recognition system development. Andrea Sassella, on the other hand, dealt mostly with business development and financial reviews.

It is also worth mentioning the work done by Andrea Rotella and Tabriz Nuruyev, respectively in the design of the algorithm and the app development, who after the first six months could not continue working with us.

Goal

As stated before, the main actor of our challenge is Pepper, the most common humanoid robot currently present in the market. The task assigned to our team by the industry partner was to identify new business applications for Pepper exploiting its empathic capabilities. Moreover, the final solution had to be the answer to a real need and be able to create value for all stakeholders involved.

As a first step of the process we deeply analyze the needs that characterize different sectors and the opportunity that the presence of a humanoid robot could have brought. This meant dividing the objectives into the first phase of exploration and research of the business opportunity and a second phase of problem framing and solution ideation.

The first objective was therefore a combination of industry and market analysis as well as a careful analysis of the value proposition that could have arisen from the needs characterizing the alternatives explored.

The second concerned a starting in-depth analysis of the stakeholders involved, as well as the problem resolution. The latter has been carried out thanks to different consequent steps: framing, the definition of specifications, ideation, validation, and the final prototyping.

Anticipating the results of the first analysis, our work was done by focusing on the fitness industry and thinking of Pepper as a technological personal trainer.

Understanding the problem

Nowadays humanoid robots are employed in several contexts, especially in the service field, becoming an integral part of industrial as well as daily activities, with the latter most interested in social robots that are most devoted to human-machine interaction.

Our partner is specialized in Intelligent Process Automation. Its core activities are the design of solutions aiming to automate business and the study of new possible ways to apply their know-how. For this reason, their request was to bring Pepper to the market under a new fashion. We started from the analysis of Pepper's limits and potentialities. Then we explored the current panorama of real applications involving Humanoid Robots in general.

Our aim was to achieve complete understanding of the market and industry regarding humanoid robots. For this reason we have explored the emerging needs in different sectors and of the potential that we could have found in Pepper to satisfy them. For this, we identified two sub-problems:

deep analysis of the current applications of Pepper to circumscribe some common traits;

identification of possible fields of application for our solution. This phase was then validated through a series of interviews. Followed by further research on possible constraints and barriers.

We deeply analyzed several applications considering the use of Pepper in retails or retirement homes, but finally, we focused on gyms by proposing Pepper as a personal trainer. This is because working in the medical field would have imposed too many constraints, while retail seemed an area already explored and with low potential.

The way people train has changed over the years, mainly due to technological progress. Indeed, today the technology for the fitness sector is constantly growing for athletes, amateurs, sports centers, or gyms. Mobile applications, chatbot, wearable devices, dedicated fitness devices, high-tech equipment, Augmented Virtual Reality Tools, Online coaching are the main categories of solutions characterizing this field nowadays.

However, some problems still exist in how people experience their gym sessions. We carried out more than 40 on-field interviews to understand the feelings of various types of people (age, gender, fitness level, ...) before, during, and after

their workouts in three types of gyms (high-tech, classic, low-cost). From the results, we defined our main goal as to democratize the role of the personal trainer in gyms. In the following ideation phase many ideas were evaluated by reasoning on the value proposition of each and the top-10 buying criteria. Our final idea was validated through more than 400 responses to a questionnaire and then finally prototyped.

Figure 3: Our prototype, Pepper with the additional equipment (camera + backpack)

Figure 4: Human body segmentation

Exploring the opportunities

The most interesting and innovative scenario that we have identified for Pepper is the healthcare one. More in detail, the gym sector is becoming increasingly competitive due to technological innovation that lowers prices and makes products more accessible. Emerging franchising gym brands are an example of this trend. They capture the attention of users of all ages and budgets, thanks to the generally low cost and high-quality machinery. This reality opens several opportunities for the use of humanoid robots as personal trainers.

In fact, Pepper can enter the sector of low-cost gyms, where the staff is usually cut to a minimum and users could feel not sufficiently monitored. This trend reduces the performance and the benefits of workout of the customers. In this context, a humanoid robot personal trainer could help the users to feel more comfortable and training assistants in monitoring procedures, by following the training of many more users at once.

Free-body exercises are most subject to errors. For this reason, they are often avoided by novices for fear of accidents. In this scenario, Pepper can be introduced as a personal trainer monitoring the quality of the executions and correcting the user when he is performing some mistakes.

Thanks to its free body exercises specialization, a possible future opportunity for Pepper would be to switch other possible applications where this type of training is relevant, such as physiotherapy and rehabilitation.

Figure 5: Pepper interaction

Generating a solution

After an in-depth analysis of users' requirements in the gym, as well as of the strengths and limitations imposed by Pepper software and hardware, the group's activity was oriented towards two main paths: the technical development of Pepper's skills and the design of the service that it will offer.

Three main functionalities had to be implemented to guarantee an efficient training session:

1. Exercise recognition;

2. Error detection;

3. Repetitions counting.

On the software side, this was achieved by using a neural network (OpenPose) for body pose segmentation, and by developing specific geometrical routines for exercise recognition and error detection. On the hardware side, it was necessary to enhance the hardware components of Pepper to speed up the algorithm execution and be able to see moves of athletes from three meters away.

This has been achieved by the addition of an external camera (Intel RealSense d435) and an external computational unit (NVIDIA Jetson TX2).

The entire user experience has been studied applying the principles of design thinking and creative problem solving, starting from the user's needs and prototyping the interaction. In particular, the user can interact with Pepper vocally, visually, and physically. On the tablet of the robot, a personalized UI has also been implemented to enhance the user experience.

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