

INTELLIGENT SPACE PARTNER

FLL RESEARCH PROJECT OF THE SAPPERS TEAM

ABOUT THE TEAM

We are The SAPPers, all students of the Alternative Secondary School of Economics in Budapest, Hungary. This is our third year participating in FLL, we really enjoyed all the seasons spent together, but sadly this is our last year of competing. We were fortunate enough to go to the World Festival in Detroit last year, where we had a wonderful time, a lot of fun, and enjoyed meeting other teams from around the world. We spend a lot of time together in school, but we also meet on weekends, and in breaks as well. Last summer three team members went to a Microsoft Bootcamp in Athens, where we learned about Artificial Intelligence, our project is based on the concept we learnt there. We want to get everything out of this last year and use all the opportunities this competition offers us.



1 Our team working



2 At the regionals

PROBLEM IDENTIFICATION - OVERVIEW

Many people suffer from loneliness and isolation, and this year we explored how people in space would react to this. Astronauts spend a lot of time in space confined to a relatively small place with only a few people. If they have an argument or just a stressful day, they do not necessarily have someone to talk to, they do not have the feeling of a secure partner, who pays attention to what they have to say. They cannot just travel back to their families or friends, and as a result of this solitude, mental problems can occur relatively often.

NASA, one of the biggest space agencies confirms this statement with the study they published in 2014¹. The research shows that 94% of the astronaut flights included the use of some kind of psychiatric drug. Also, according to the document, 74% of ISS's crew members use sleeping pills, and insomnia is also a side effect of many mental illnesses. NASA makes a great effort to find the solution to this problem².

Astronauts work in a high-pressure, high-risk environment and at a great distance from Earth. The mental health of the crew is key to a successful mission³. During the early Apollo missions, astronauts reported flashes or streaks of light coming out of nowhere. In 2012, on the ISS, Don Pettit described these actions as "flashes in my eyes, like luminous dancing fairies". These hallucinations are also caused by serious mental disorders that cannot be overlooked. Living hundreds of kilometres away from your home planet, having a stressful job and just a few comforts being in your life leads to a bad environment for working. Many basic mental skills work less well in space like coordination, task solving, decision making, researchers found. With having longer missions further away from Earth, say, going to Mars, the seriousness of this issue can escalate.

But how can this problem be solved? That is the question we were trying to answer, and that is how we came up with ISP.

¹ <https://blogs.scientificamerican.com/guest-blog/mental-health-in-outer-space/>

² <https://academic.oup.com/milmed/article-abstract/158/1/5/4844141>

³ <https://www.theguardian.com/science/2014/oct/05/hallucinations-isolation-astronauts-mental-health-space-missions>

THE SOLUTION AND ITS OPERATION

We tried to create an innovative and useful solution, and we think we were successful. The solution is a personalized partner for astronauts who spend a lot of time alone in space. ISP, short for Intelligent Space Partner, uses Artificial Intelligence and assesses the psychological state of the user based on its facial expressions and communication. ISP can be a secure partner for the scientists and astronauts during a long journey through space. When the robot detects signs of a mental problem, it notifies a therapist on Earth, this way the therapist and the superior of the astronaut can take steps to help.

ISP must be perfectly matched to the user, so first the astronauts have a personal interview. They have to answer a series of questions and the robot's appearance is created based on their requirements and personality. The astronauts get to know their partner during the training period, so the relationship would form quite quickly. This is particularly important because this is the learning stage for the robot as well, the machine learning can be personally trained during this time. The meeting is important from the user's side as well, because ISP is only effective if they have a close, personal contact. This is the time, when modifications can be done if needed.

During the time in space ISP is with their partner at all times, and its camera and voice microphone would be constantly recording. Obviously, this personal information would be only available to the astronaut's therapist, if needed. If the ISP detects unusual behaviour on its partner, which can be caused by a mental illness it notifies the doctor immediately. The robot replaces a secure partner in the isolated environment, so there would be a smaller chance that astronauts get mental disorders. The crewmembers have somebody to talk to, who listens to them, and helps in case they need it. The machine learning can be helpful in identifying sign of problems even before a specialist could do so. This way we could prevent the problems before they turn serious.

We also think that ISP can be a partner for lonely and isolated people on Earth. According to the University of California, 40% of seniors experience loneliness regularly, and this can lead to serious health problems⁴. We think having a partner they can rely on can change their condition, so ISP could help in monitoring their mental state.

We created a prototype, which works with a Google AIY vision kit. It recognizes the human face and its expressions using machine learning. The hardware includes a dedicated board for running image recognizing neural networks. We tested the joy detection on our classmates, and it worked well. We want to make the voice recognition part as well using the Google Voice Kit.

⁴ <https://stonegatesl.com/one-is-the-loneliest-number-combating-senior-isolation/>

INNOVATION

The first thing we did, right after choosing the topic we want to work on, was to look at the earlier solutions, so we do not create something which already exists. We searched for solutions to mental illnesses caused by isolation and loneliness. We found online chatbots, to whom the user can talk to, not to feel lonely. Examples include SimSimi, Sass Bot, and Mydol⁵, but they can be used for entertainment purposes only, they cannot solve serious problems neither can they replace a therapist, a close friend, or a family member. There is another problem with the chatbots, which is the unreliable internet connection on the spaceships.⁶

CIMON, an AI based assistant for astronauts is already used on ISS⁷. It was created to help astronauts to carry out scientific experiments, and it can answer the crew's verbal questions. But CIMON is clearly not an answer to our problem, the user cannot have a personal relationship with it, it was not created for this purpose.

During the creation of ISP, we used the Harlow-test⁸ as a starting point. It shows that it is much easier to create a close connection with a furry creature, and that is why our robot is more like a pet than a human. The robot's appearance takes advantage of our innate child-care instinct too. It has a big head and big eyes, and research shows that it is easier to let a baby-like creature closer to us.

Each ISP is created for one astronaut, so it can be perfectly personalized. It is very important, that the talking partner is represented in reality, as that is why you can have a real relationship with it, unlike with the chatbots.

ISP can create a complex psychiatric assessment using machine learning. It is a very common problem with psychiatric patients that they are not aware of their condition, therefore they do not ask for help. This would be prevented by ISP. When the robot detects an irregularity, it notifies the therapist, this way Artificial Intelligence and human specialists work together.

During the first Mercury missions, the astronauts who were used to flying planes had some tasks to do in the cockpit, which did not really have an impact on the flight but occupied the astronauts who were not used to being idle during a mission. ISP would be a great way to prevent astronauts from boredom. They must take care of their robot, and because of the personal dependence, it also shows some kind of mental problem if the user neglects their ISP.

⁵ <http://www.simsimi.com/ChatSettings>, <https://chatfuel.com/bot/Sass-Bot-210922363027998>, <https://play.google.com/store/apps/details?id=com.wacompany.mydol&hl=en>

⁶ <https://www.theatlantic.com/technology/archive/2015/06/the-internet-in-space-slow-dial-up-lasers-satellites/395618/>

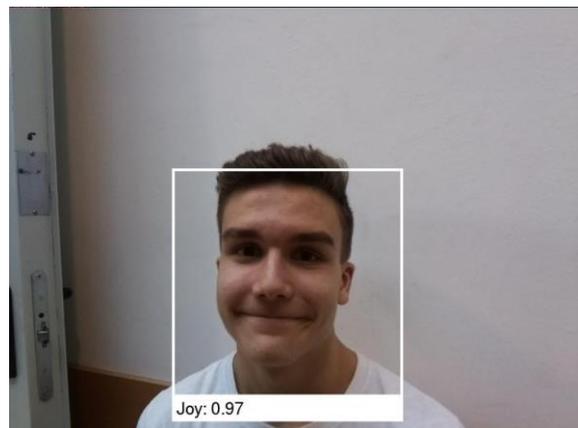
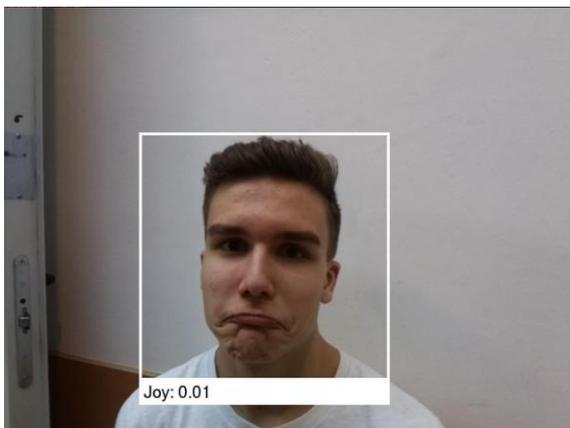
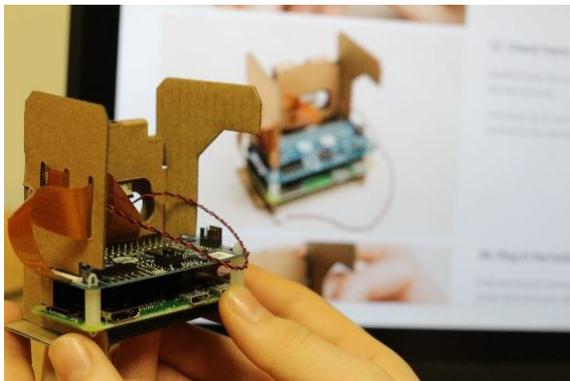
⁷ <https://www.space.com/42574-ai-robot-cimon-space-station-experiment.html>

⁸ <https://www.psychologynoteshq.com/psychological-studies-harlows-monkey/>

SOLUTION DEVELOPMENT

We explored the options to meet the requirements and wanted to implement the best solution. We started the whole process with a brainstorming session followed by information gathering about long-haul space travel, and the concerning problems.

The most common problems were psychological illnesses. Next, we started thinking about innovative solutions for these problems. This is how we came up with the ISP. We have talked to several experts during our development process, including Anna Pálinkás, psychologist, Mike Drever and Jacob Cohen NASA employees, Barna Pásztor, AI expert, and Nándor Fa, sailor, who circumnavigated Earth alone, and who told us about the difficulties of spending a lot of time alone. “I believe that psychological applications would be a great benefit of the human kind.” - said Barna. According to Jacob, “Telemedicine is important for medical diagnoses in extreme environments and in locations where medical services are not available.” They all agreed on the creativeness and helpfulness of our solution.



3 Building the prototype

We used several softwares during the development of the ISP. We created a speech recognition part in LUIS⁹ that puts the user's sentences into predefined classes so that it can assess its status. We created a facial expression recognizer in Custom Vision¹⁰. It works on a similar principle, but images are fed into the program. These were useful for us to get an insight into the world of AI. We used the AIY Vision Kit¹¹ to create the prototype. We also want to develop the product so that it will be able to understand the speech of the astronaut. We are also planning to create personalized training sets for multiple users and another machine learning algorithm that will be able to classify the user's intonation.

IMPLEMENTATION

The ISP is a stuffed animal-like robot. The user can choose the animal and its look, so it would be more personalized. This way each and every ISP would be a unique item. Every astronaut, or user would have a personalized partner and its appearance would be based on their personal taste, so all robots have to be made individually.

Being such a unique item, that must operate in a very special environment (for example on a space station) prohibited us from making a full implementation of it, but we could make approximations using several existing technologies (LUIS, Custom Vision and the AIY Vision Kit as mentioned earlier).

According to our calculations, a prototype would cost 140 USD. When doing our market research, we discovered a slightly similar product, Woobo¹². This is for kids and it is used for entertainment purposes only, not as device for mental hygiene. This costs about 150 USD. To make ISP work in space we must attach some other mechanisms to it. The robot must move in the spaceship, and in zero-gravity this is not that easy. ISP will be able to fly around, by sucking air in and expelling it through special tubes, that is how CIMON works. To communicate with the therapist on Earth ISP must be connected to a wi-fi network. With the built in Raspberry-pi this is already achieved, as the small computer can send information provided the connection is established. It is also important that the AIY kit has a special board for running neural networks, which means that it can save energy and bandwidth by running the neural networks onboard.

We prepared our prototype by putting the AIY kit and a power bank inside a stuffed animal and monitor the expressions of people interacting with it. We found that this system works well, the students of our school were happy to handle the companion.

As a market research, we talked to experts at NASA as mentioned before, who said that our idea could be a useful solution to a real problem. The costs of finalizing and manufacturing the ISP would be negligible compared to the total costs of a space mission.

⁹ <https://www.luis.ai/home>

¹⁰ <https://www.customvision.ai/>

¹¹ <https://aiyprojects.withgoogle.com/vision/>

¹² <https://www.woobo.io/>



We believe with the use of ISP we can make astronauts' life easier and more wonderful!