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XXXIII Cycle - II year presentation

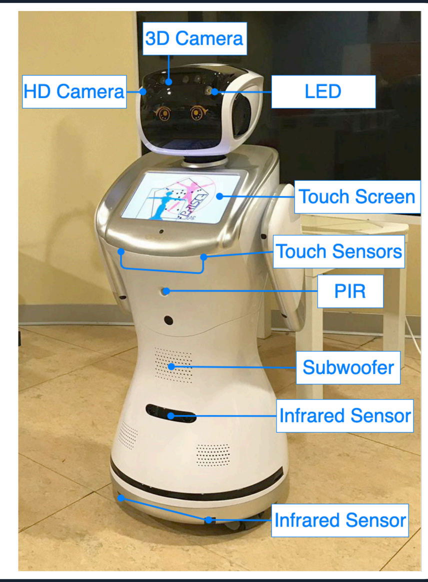
Machine Learning for Activity Recognition and User Profiling

CONTEXT

- Socially Assistive Robots are used in many domains like entertainment, education and health-care.
- They focuses on helping human users through social interaction.
- **UPA4SAR** project is aimed at **assisting with mobile robots in the fields of health and social care** for **assisting elderly people affected by dementia**.

MOTIVATION

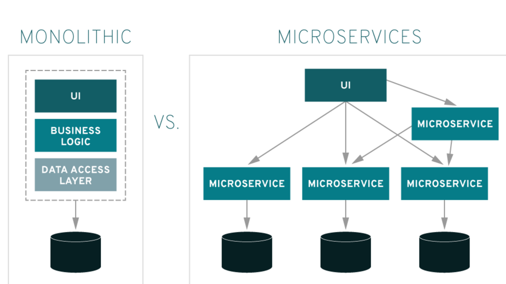
- In the domain of elderly assistance, where the patiances have cognitive problems and senile dementia, these people may need assistance and continuous monitoring.
- **Modular architecture for robot behavior personalization** regulating its social interaction parameters based both on the personality factors and on the cognitive state of the user.
- **Monitoring the instrumental activities of daily living** (iADL) through the use of a mobile robot system.
  - A fundamental feature of the project is the cost-effectivness.
- We currently test the robot in real users' houses for a year.



IDEA

- [1] We focused on the implementation of the behaviors following a Robot as a Service (RaaS) approach, by breaking complex behaviors in a series of primitive services (microservices). The combination of the microservices allows to obtain modular and scalable functionalities.
- [3][4] We implemented a two-step framework composed by a deep learning model based on CNN and LSTM for Activity Recognition and a GMM model for Novelty Detection.

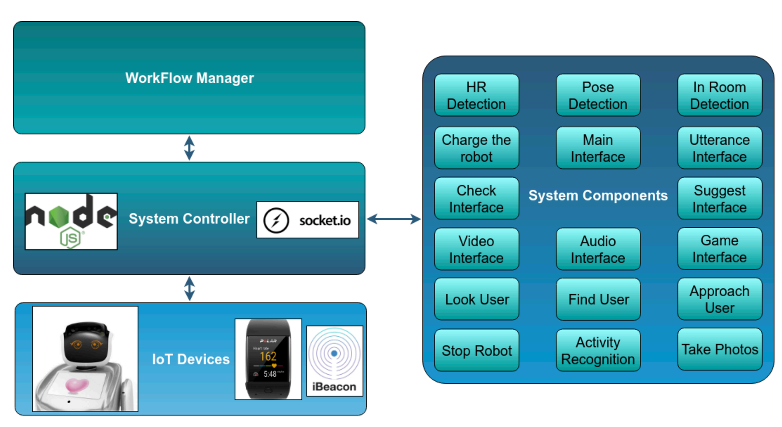
METODOLOGY



- Dividing all functionalities required from the robot into a series of basic and primitive cohesive functionalities that we call microservices
- The microservices are independent and directly testable in isolation with respect to the whole system
- They have their own container with their configuration, dependencies, responsabilities and programming language
- Scaling is simple and they foster continuous integration for an easy maintenance

DEVELOPMENTS

- Workflow Manager: schedules the robot behaviour to assist the elderly
- System Controller: server implemented using Node.js that handles the communications with others via «Socket.IO» library
- IoT Devices: robot, smartwatch, beacons, smartphone
- Monitoring Services
  - Recognition of poses, activities [3][4], gestures, emotions, disengagement via wearable device or camera
- Navigation Services
  - Searching and approaching the user
- Interaction Services
  - Speech recognition and synthesis, UI Interfaces



RESULTS

Three experimental settings:

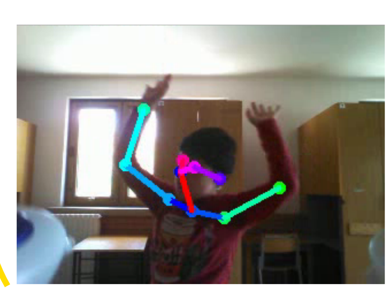
- Test 1: No obstacles between the robot and person
- Test 2: An obstacle between him and the person
- Test 3: An obstacle between the robot and two possible interlocutors

	Look User	Find User	Approach
Test 1	$21.27s \pm 5.00s$	$65.63s \pm 13.74s$	$98.90s \pm 24.87s$
Test 2	$19.52s \pm 7.77s$	$75.00s \pm 12.68s$	$190.97s \pm 94.24s$
Test 3	$16.23s \pm 2.69s$	$70.28s \pm 13.52s$	$114.82s \pm 58.58s$
Mean	$19.01s \pm 5.15s$	$70.30s \pm 13.31s$	$134.90s \pm 59.23s$

Server: Intel NUC7i7BNH with intel i7-7567U – 3.50 GHz, 16 GB DDR4 RAM and 256 GB SSD

GESTURE RECOGNITION

- Preliminary investigation on gesture recognition using video recorded by the embedded camera on NAO robot that support clinical procedure
- The dataset is composed by video recorded during CARER-ID [2] experiments addressed to children with Autism Spectrum Disorder (ASD) with Intellectual Disability (ID) (the children had to imitate the robot gesture)
- A deep model based on LSTMs and three evaluation settings are proposed
- The best results overcome the 90.00% of accuracy



Timestep	Setting	Acc. step 1	Acc. step 2
5	Already Seen	94.56%	94.13%
5	Interleave	92.49%	91.92%
5	Leave Child Out	91.99%	91.42%
10	Already Seen	92.70%	94.56%
10	Interleave	91.42%	91.49%
10	Leave Child Out	90.14%	90.35%

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FUTURE WORK

- Further evaluations, deploying the whole system proposed, will be produced in the current experimentation with 8 elderly patients affected with Alzheimer's disease
- Enhancement of face recognition (that is based on only three picture for each subject) via the selection of the picture of the subject to be recognized with a new approach base on clustering algorithm
- Enhancement of the real time activity recognition via camera using Open Pose (recognition from 2D skeleton data instead of 3d skeleton data), classical machine learning and feature extraction techniques, recording of more motion data from the activity performed to guarantee the best results with novel deep learning approaches
- Comparison between HMM and LSTM on skeleton data sequences/series.

[1] Ercolano, G., Lambiase, P. D., Leone, E., Raggioli, L., Trepiccione, D., Rossi, S. (2019, October). Socially Assistive Robot's Behaviors Using Microservices. In *2019 28th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN)*. IEEE.

[2] Conti, D., Trubia, G., Buono, S., Di Nuovo, S., & Di Nuovo, A. (2018, July). Evaluation of a robot-assisted therapy for children with autism and intellectual disability. In *Annual Conference Towards Autonomous Robotic Systems* (pp. 405-415). Springer, Cham.

[3] Rossi, S., Bove, L., Di Martino, S., & Ercolano, G. (2018, November). A Two-Step Framework for Novelty Detection in Activities of Daily Living. In *International Conference on Social Robotics* (pp. 329-339). Springer, Cham.

[4] Ercolano, G., Riccio, D., & Rossi, S. (2017, August). Two deep approaches for adl recognition: A multi-scale lstm and a cnn-lstm with a 3d matrix skeleton representation. In *2017 26th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN)* (pp. 877-882). IEEE.