Walking Machine @Home
2019 Team Description Paper

Jeffrey Cousineau, Huynh-Anh Le, et al.

École de Technologie Supérieure
1100 rue Notre-Dame Ouest, Montreal, QC, Canada H3C 1K3
http://walkingmachine.ca, walking@ens.etsmtl.ca,
https://github.com/WalkingMachine

Abstract. This paper gives details about the RoboCup@Home league team Walking Machine, from ETS University in Montreal, Canada for the next competition in Sydney, in July 2019. The robot from Walking Machine, named S.A.R.A. for "Systeme d'Assistance Robotique Autonome" (in English, Automated Robotic Assistance System), is a robot entirely built by the scientific club from ETS, mainly composed of undergraduates students. The robot is used for social interaction with humans, navigation and object manipulation. This document shows the electrical, mechanical and software novelties and functionalities of S.A.R.A.

1 Introduction

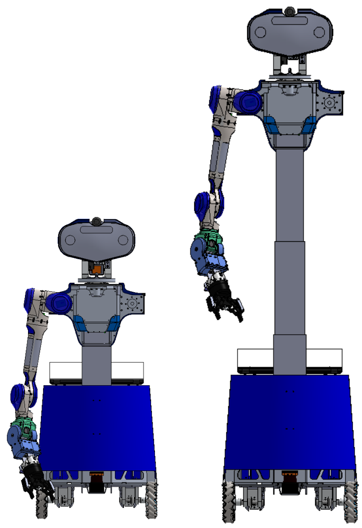
Walking Machine's team is a young team from Montreal, Quebec, in Canada, composed of engineering students in the field of mechanical, electrical and software engineering. We have been working really hard to improve our robot for the next year Robocup@Home competition. As this would be our fourth participation, we learned a lot at Montreal Robocup and we made many improvements to get better results, mostly on the software side. In the past, the team went in many competitions like the Eurobot, but made the leap for the RoboCup@Home competition to get a bigger challenge and to get an opportunity to bring novelty in the scientific community surrounding robotic.

SARA, our creation, was designed for polyvalent human-robot interaction as well as efficient navigation and object manipulation. Our robot is mounted on four mecanum wheels powered by Roboteq drives, has one arm mimicking a normal human arm, and sensors for communication and navigation. Our team has developed knowledge in object and people detection/recognition, as well as navigation using a laser scanner, odometry on the wheels and a Asus Xtion camera. All of these parts are interfaced through ROS (Robot Operating System).

2 Mechanical improvement

2.1 Mechanical

To improve our robot habilities, we decide to add a vertical linear actuator, more specifically, a TL5 column made by TiMOTION. This will add a degree of freedom, giving us a wider range of motion to reach objects on the floor or higher on the cupboard shelves. This will be really helpful for challenge like storing groceries where the objects can be anywhere in the cupboard.



(a) Lowest point (b) Highest point

Fig. 1: S.A.R.A. linear actuator motion range

We also decided to improve our wrist by adding a gearbox, giving it more strength. We took the decision to improve it after having problems with the gripper being too heavy.

3 Software

3.1 Natural language understanding

To convert spoken data in actions subset, we had to create our own natural language understanding system. To do this, we based ourself on rasa nlu[2], an open-source nlp tool for intent classification and entity extraction. But a simple entity extraction wasn't enough for us, we wanted a system that would take a command as an input and output the desired actions.

To do this, our first step was to create a dataset for the entity classification. Based on the GPSRCmdGen, we generated sentences which we hand labeled by attributing an entity to each specific type of sentence.

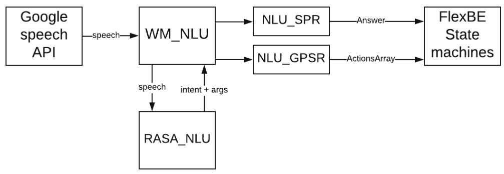


Fig. 2: Natural language understanding process

3.2 Sound localization

3.3 Object recognition

For our object recognition, we use YOLO [4], a real-time object detection. It does not only detect various object but it also predicts the bounding boxes of the detected object. It uses a single neural network which is applied to the image. Multiple regions are then created and are used to predict the bounding boxes. Each of them also contains the predicted probability which is used to filter the predicted objects. The advantage of this system is that it can detect multiple objects in a real-time scenario.

3.4 Objects and people tracking

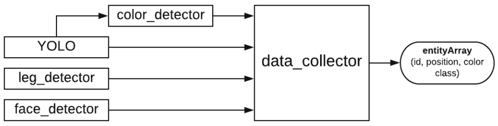


Fig. 3: wm_data_collector process

4 Conclusions and future work

Pourrait être rephrasé. As you can see, despite being a group of undergraduate students, our team is about to catch up with the rest of the league. We've recently put a lot of efforts into stabilizing our platform and fixing as many bugs as possible to give us a strong foot to move forward.

Actualiser le dernier paragraphe. With its new swappable batteries system, object detection network and natural language processing, our robot has become a fully functional autonomous platform allowing us to focus our efforts on the challenges themselves instead of continuously fixing our hardware.

Robot SARA Hardware Description

Specifications for robot SARA are as follows:

SARA	
Base	Custom base with fully holonomic platform
Vertical column	Timotion TL5
Right arm	7 DoF custom arm made of Kinova motors and dynamixels
Neck	Tilt and pan unit using two Dynamixel MX-64R servo actuator
Head	Custom head made of RGB neopixels leds and Asus Xtion Pro
Gripper	Robotiq 2 fingers 140mm
Dimensions	Base : 0,61m. X 0,77m. Height : 1,48m.(min.) 1,78m.(max.)
Weight	~70kg
Additional sensors	Hokuyo UTM-30LX on base
Microphone	Rode microphone and Matrix Creator
Batteries	2x 20V Dewalt drill battery 5aH
Computer	1x Lenovo p50 with 32GB RAM and nVidia Quadro M2000 4GB, 1x Raspberry Pi 3, 1x Nvidia Jetson TX2

Table 1: Robot's hardware description

Robot's Software Description

For our robot we are using the following software:

- Platform: Robotic Operating System (ROS) Kinetic on Ubuntu 16.04
- Navigation, localization and mapping: Gmapping, AMCL, pointcloud_to_laserscan
- Face recognition: People
- Speech recognition: Google Speech API
- Speech comprehension: LU4R, lu4r_ros
- Speech generation: Svoxpico
- Object recognition: Darknet with YOLO v2
- Arm control: MoveIt and Kinova API
- Task executor: Flexbe
- World reprensentation: Wonderland

Fig. 4: Robot SARA

Team members

André-Philippe Audette, Nicolas Bernatchez, Pierre-Emmanuel Billeau, Jeffrey Cousineau, Raphael Duchaine, Quentin Gaillot, Louis-Charle Labarre, Philippe La Madeleine, Redouane Laref, Vincent Lavoie-Marchildon, Huynh-Anh Le, Lucas Maurice, Alexandre Mongrain, Jimmy Poirier, Veronica Romero Rosales

References

1. LU4R Project - adaptive spoken Language Understanding For Robots.
2. Rasa nlu: Language understanding for chatbots and ai assistants.
3. Zhe Cao, Tomas Simon, Shih-En Wei, and Yaser Sheikh. Realtime multi-person 2d pose estimation using part affinity fields. In *CVPR*, 2017.
4. Joseph Redmon and Ali Farhadi. Yolo9000: Better, faster, stronger. *arXiv preprint arXiv:1612.08242*, 2016.
5. Philipp Schillinger, Stefan Kohlbrecher, and Oskar von Stryk. Human-Robot Collaborative High-Level Control with an Application to Rescue Robotics. In *IEEE International Conference on Robotics and Automation*, Stockholm, Sweden, May 2016.
6. Bruno Siciliano and Oussama Khatib, editors. *Springer Handbook of Robotics*. Springer, 2016.
7. Roland Siegwart and Illah R. Nourbakhsh. *Introduction to Autonomous Mobile Robots*. Bradford Company, Scituate, MA, USA, 2004.
8. Tomas Simon, Hanbyul Joo, Iain Matthews, and Yaser Sheikh. Hand keypoint detection in single images using multiview bootstrapping. In *CVPR*, 2017.
9. Shih-En Wei, Varun Ramakrishna, Takeo Kanade, and Yaser Sheikh. Convolutional pose machines. In *CVPR*, 2016.
10. Stephen J. Wright. Coordinate descent algorithms. *Math. Program.*, 151(1):3–34, June 2015.