Trekking/Robo-Magellan Project

ThundeRatz Robotics Team
Escola Politécnica da
Universidade de São Paulo
contato@thunderatz.org

I. Introduction

A. The team

Founded in 2001 by a group of engineering undergraduate students from University of São Paulo (USP) to bring the international robot combat competition to Brazil, the team does research and development on robotics in the biggest university in South America. Throughout the years, it expanded into more categories and competitions, with highlight on its internationally awarded sumo robots [1] and Robo-Magellan [2]. After over 15 years of experience, learning and university research, the ThundeRatz team [3] has some of the most known and award-winning robots of Brazil, reason of pride to the members and motivation for more innovations.

B. The project

Trekking [4] and Robo-Magellan are two competition categories involving autonomous robots emphasizing navigation and obstacle avoidance over varied, outdoor terrain. Their goals are autonomous movement and localization. Both are explained in detail later.

II. Goals

The team's main goal is the dissemination of knowledge between its members and the advancement of robotics nationally through innovations and research. To this end, the project follows some guidelines:

1) Open-source: Code from past competition editions is open-source and published at the team's GitHub page [5].

2) Affordable: Initial versions of the project used a Raspberry Pi, USB camera, compass and GPS, building a cheap but competitive robot. We are investing in more advanced technologies to keep the project up-to-date with international competitions, but most of its concepts can be implemented without a high cost.

3) Shared knowledge: Lots of knowledge and experiences are shared in the competitions and a warm friendship environment is kept with other teams. Furthermore, the robot is shown in philanthropic events and expositions.

The goals currently set for the project are:

A. Increased reliability

Use sensor redundancy and sensor fusion algorithms [6] to enhance reliability under bad conditions.

B. SLAM research

Try to use laser based SLAM techniques for location and evaluate different SLAM algorithms. Existent laser SLAM CUDA solutions are mostly under development [7], but some are complete [8] and papers and other universities' research are available [9]. If possible, use existing or create CUDA solutions based on current research.

C. Avoid problems in electronics

Problems in electronics had major consequences in the results from the last competitions. Therefore, it is necessary to make hardware connections more reliable.

I. Competitions

Competitions create a friendly environment to share ideas and experiences with other teams and evaluate the project's advancement. The robot takes part in two similar autonomous categories.

A. Trekking

Trekking is a national category hosted at the Winter Challenge and Summer Challenge competitions. Both are hosted by RoboCore [10], a company specialized in robotics, and are our main competitions. The Trekking category's goal is the construction of a robot to locate white boards on an open grass field. The boards can be optionally marked with an orange traffic cone.

B. Robo-Magellan

Robo-Magellan is an international category held by the Seattle Robotics Society (SRS) [2]. An autonomous robot is assigned to locate orange traffic cones hidden in an environment with obstacles. There is no straight-line path between the start and destination points without some significant obstacle. The robot must locate and touch as many cones as possible.

II. Project details

We strive to maintain a competitive and evolving project. Project achievements can be seen at section III.

A. First iteration

The first version of the robot used a compass, GPS and USB camera. It's four wheel layout with traction on all wheels was kept in later versions, although the chain transmission was changed. OpenCV was used for computer vision. A Raspberry Pi was used for processing and a router was included for wireless programming and debugging.

Fig. 1. Disassembly with electronics exposed. From left to right: router, Raspberry Pi B, motor controller

Fig. 2. Robot at Winter Challenge X (São Paulo, Brazil), 2014

Fig. 3. Robot at Campus Future (Campus Party 2015) [11], open exposition of new engineering projects

B. Second iteration

The robot went through changes to compete on the Robo-Magellan category. The weight limitation, which doesn't exist on the Trekking category, required a lighter structure. We also used faster motors. The USB camera was replaced by a CMUCam 5, camera with integrated image processing and color detection. HC-SR04 sonars were added to detect the distance to the traffic cones. It was its first international competition and the team's first time at the United States.

Fig. 4. RoboGames 2015 (San Mateo, CA)

Fig. 5. Third place at RoboGames 2015

C. Third iteration

The third iteration was smaller and lighter. Embedded computer vision in real time was made possible due to the Jetson TK1 board granted by NVIDIA, using an USB webcam. The sensors used for robot localization were a GPS device and a 9-axis IMU. Furthermore, a lidar sensor was used for obstacle avoidance. The robot was used in Winter Challenge XI, but due to problems in our electronics it got 5th place. It was also used in Summer Challenge III, achieving 2nd place, RoboGames 2016 on 3rd and Winter Challenge XII on 4th.

Fig. 6. Robot structure

Fig. 7. Raspberry Pi B 2.0 with team-made GPS module

Fig. 8. Winter Challenge XI (São Paulo, Brazil), 2015

D. Fourth iteration

This is the current version of the project. A RC car model is now used as the robot's structure and motion system. The electronic had to be adapted to this model. In addition to the sensors of the previous version, a magnetic encoder is used for localization. The computer vision was greatly improved by an object detection neural network. However, the frame rate during inference is not as high as desired (currently around 8 FPS), which limits the speed of the robot. Therefore, a better GPU is needed. Also, ROS [13], which foster a large community of user-contributed packages, began to be used in the current version. The robot was used in Winter Challenge XIII (2017), but due to problems in our electronics it achieved fourth place.

1) The neural network: The neural network used in this project is Darknet's YOLO [12], which is an object detection network. This kind of network infer the type and localization of an object in an image. The dataset for training was built with help from the entire team.

2) ROS: Apart from using user-contributed packages from the ROS community, we have also created a package to integrate YOLO with ROS. This package is used in this version of the project, but it is free for public use.

Fig. 9. Winter Challenge XIII (São Paulo, Brazil), 2017

Fig. 10. Cone detection using Darknet's YOLO neural network, 2017

III. Past achievements

Our robot is one of the national favorites. Following is a list of past achievements.

2014

1) Winter Challenge X: Third place

2015

1) *RoboGames 2015:* Third place
2) *Winter Challenge XI:* Fifth place
3) *Summer Challenge III:* Second place

2016

1) *RoboGames 2016:* Third place
2) *Winter Challenge XII:* Fourth place

2017

1) *Winter Challenge XIII:* Fourth place

IV. Partnership

Companies willing to help the project are encouraging university research and knowledge dissemination. Partner companies get their logo on the robot and team's t-shirts, which are worn by the team's members in competitions, expositions and in daily activities in the university.

Acknowledgment

We gratefully acknowledge the support of LeddarTech with the donation of the Leddar Sensor Evaluation Kit and NVIDIA Corporation with the donation of the Jetson TK1 GPU used for this project.

References

[1] FSI-All Japan Robot-Sumo Tournament. *Robot Sumo Overview*. http://www.fsi.co.jp/sumo-e/out/out00000.html
[2] Seattle Robotics Society. *SRS Robo-Magellan*. http://www.robothon.org/robothon/robo-magellan.php
[3] ThundeRatz Robotics Team. http://thunderatz.org/
[4] RoboCore. *Trekking rules*. https://www.robocore.net/upload/attachments/robocore__regras_robo_trekking_976.pdf
[5] GitHub. *Thunderatz Robotics Team* https://github.com/ThundeRatz
[6] SourceForge. *KFilter*. http://kalman.sourceforge.net/
[7] Chee Sing Lee. *PHD Filter SLAM with CUDA* https://github.com/cheesinglee/cuda-PHDSLAM
[8] Felix Endres. *Rgbdslam v2* http://felixendres.github.io/rgbdslam_v2/
[9] Haiyang Zhang, Fred Martin. *CUDA Accelerated Robot Localization and Mapping* http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6556350
[10] RoboCore. *Sua tecnologia à prova*. https://www.robocore.net/
[11] Campus Party. *Campus Future*. http://brasil.campusparty.org/conteudos/open-campus/campus-future/
[12] Darknet's YOLO. *YOLO: Real-time object detection system*. https://pjreddie.com/darknet/yolo/
[13] ROS. *Robot Operating System*. http://www.ros.org/
[14] YOLO integration with ROS. *ROS YOLO*. https://github.com/ThundeRatz/ros_yolo2