EINDHOVEN UNIVERSITY OF TECHNOLOGY

PDEng Mechatronic System Design

Mathematics and Computer Science Department

Autonomous Referee System

Feasibility of TechUnited TURTLES

Project Team 2021

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Contents

1 Introduction

Tech United Eindhoven represents the Eindhoven University of Technology in the RoboCup competitions (the Middle-Size League). As of this year, 2022, the robot platform that is exposed by Tech United is called TURTLE, stating for Tech United RoboCup Team: Limited Edition [1]. The TURTLEs can autonomously play soccer, which means that they are able to perceive the environment, localize, follow the ball and shoot on the goal without human interaction. Based on the data collected from TURTLEs, the world model is created which collects the infromation about the environment, position of the players, ball and additional information used for soccer strategy. The idea is to use the processed data by turtles to know the state of the game and based on this information make referee decisions.

2 Robot Platform

The TURTLE is equipped with two perception sensors, which are 'OmniVision' camera and a Microsoft Kinect 2 camera. 'OmniVision' camera is a 0.3-megapixel camera aimed at a convex mirror on top with the field of view of 6 m and limited to 80 cm height view. A Microsoft Kinect 2 camera is a 2-megapixel camera, which is able to recognize the depth and is used to recognize the ball when it is above 80 cm (constraint of 'OmniVision'). Additionally, due to high symmetry of the field, TURTLEs are also equipped with a compass to know the orientation of the robot. These sensors are mainly used in localization and object detection. To estimate the position of the TURTLEs, wheel encoders are additionally considered. However, the main source of perception is 'OmniVision' camera.
It is worth mentioning that we do not consider extraction of the raw data from the sensors. There is already algorithm that is implemented by Tech United to detect the objects and localize the robot. Moreover, the images from 'OmniVision' camera are distorted due to fish-eye view.

3 Software

The Tech United software is useful for the control of the soccer robots on the field, for real time data acquisition of the robots, for making simulations of soccer matches and practicing different scenarios.
The Tech United software is available publicly through the following GitLab repository: *Tech United Public Repository*: `https://gitlab.tue.nl/tech-united-eindhoven/Turtle3`.
However, it may not be the latest version of the repository. In order to access their private repository, you need to sign up for Tech United GitLab, which is different from TU/e GitLab, and from there you can access the latest version of the repository (*Tech United Private Repository*: `https://gitlab.wtb.tue.nl/users/sign_in`). One screenshot is given in Figure 1.

Note: It is strongly recommended to get the software from their private repository, otherwise, there might be some issues in running the software.

3.1 System Setup and MATLAB installation

To setup the system and installing the MATLAB for using the software, it is necessary to install Linux on your system. It is recommended to be in contact with members of Tech United team who are working in the Robotics Lab.

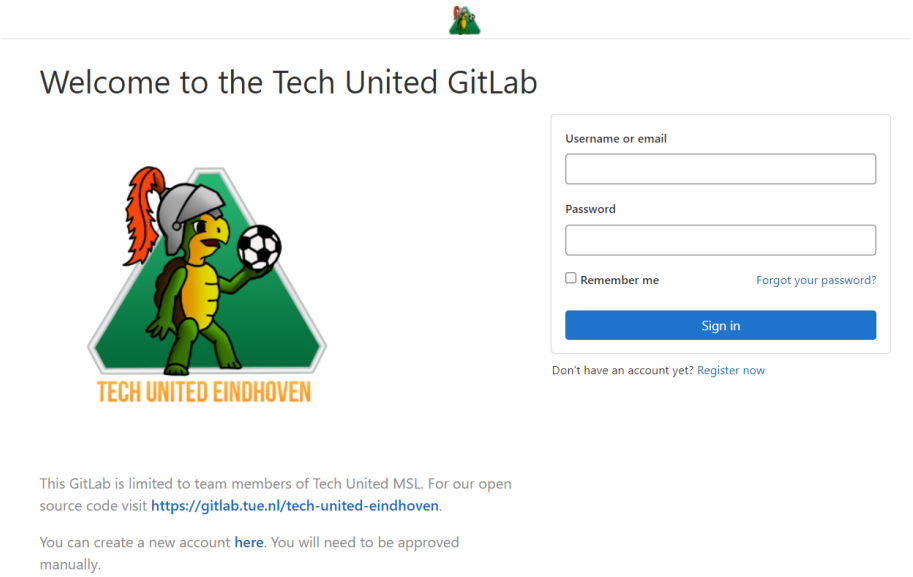

Figure 1: Tech United GitLab

In order to have access to the installation guide of the software, it is necessary to register in the following website: *Installation Guide Website*: `https://redmine.wtb.tue.nl/account/register`. Then, you can have access to the complete installation guide through the following link: *Installation Guide Document*: `https://redmine.wtb.tue.nl/projects/tech-united-msl/wiki/DevPC_with_Ubuntu_2004`.

As of February 2022, the main steps for the installation are as follow:

- The operating system should be **Ubuntu 20.04 64 bits**.
- The username and computer's name of the system should be:
  - username: robocup
  - computer's name: devpc# (where # is a number below 35)
- The follwoing packages need to be installed on the system. In the terminal execute the following commands:

```
robocup@devpcX:~$ sudo apt update
robocup@devpcX:~$ sudo apt upgrade
robocup@devpcX:~$ sudo apt install build-essential libcjson-dev libjson-c-dev
    cmake flex glade automake openssh-server libopencv-dev ffmpeg libusb
   -1.0-0-dev bison valgrind ccache gconf-editor nfs-common zlib1g-dev
   openjdk-11-jre-headless libpng-dev libsdl-image1.2 cpufrequtils libssl-
   dev git git-lfs libxml2-dev libcunit1-dev xterm vim sshpass htop net-
   tools libgtkmm-3.0-dev
```

- Install MATLAB 2020b (It may works with newer versions but it is not guaranteed):

  In order to download MATLAB you can use the following link and access to the different releases. You need to login by your Mathworks account: `https://nl.mathworks.com/login?uri=%2Fdownloads%2Fweb_downloads%2Fdownload_release%3Frelease%3DR2020b`.

  - The complete installation guide for MATLAB can be found in these two links:

1) `https://redmine.wtb.tue.nl/`, which needs registration;
2) `https://redmine.wtb.tue.nl/projects/tech-united-msl/wiki/Matlab2020b`;

– The following packages need to be installed with MATLAB during the installation:

```
MATLAB
Simulink
Computer Vision Toolbox
Control System Toolbox
DSP System Toolbox
Financial Toolbox
Image Processing Toolbox
MATLAB Coder
MATLAB Compiler
MATLAB Compiler SDK
Model Predictive Control Toolbox
Optimization Toolbox
Signal Processing Toolbox
Simulink Coder
Simulink Compiler
Statistics and Machine Learning Toolbox
Symbolic Math Toolbox
```

During installation, a folder for symbolic links is asked for. Enter:

```
/usr/local/bin/
```

– You need to use your TU/e password to activate MATLAB during or after the installation.

– There are bugs that needs to be fixed. After the installation, you should execute the following two commands in the terminal:

```
1 mv /usr/local/MATLAB/R2020b/sys/os/glnxa64/libstdc++.so.6 /usr/local/
    MATLAB/R2020b/sys/os/glnxa64/libstdc++.so.6.old
2 mv /usr/local/MATLAB/R2020b/bin/glnxa64/libxml2.so.2 /usr/local/MATLAB/
    R2020b/bin/glnxa64/libxml2.so.2.old
```

– **Configure MATLAB:**

∗ Set mex options of MATLAB, in a terminal execute:

```
1 robocup@devpcX:~$ sudo su
2 root@devpcX:~$ matlab
```

In MATLAB execute the following:

```
1 >> mex -setup
```

select the first one OR, if MATLAB selects gcc as default and no option to choose is given, this is okay as well!

∗ In a terminal execute:

```
robocup@devpcX:~$ sudo gedit /root/.matlab/R2020b/mex_C_glnxa64.xml
```

replace

```
-ansi
```

on line 19 by:

```
-Wall -Wextra -Wno-unused -Wno-comment -Wno-implicit -Wno-unused-but-
    set-variable
```

- In the main directory of the repository in MATLAB, right-click the file addpathrobocup.m and select Run. Next, go to File then Set Path... (or type pathtool in your command window). Click on Save and close the window.
- Inside the MATLAB you should define a variable called 'ROBOCUP_REPO_PATH'. It can be defined as an environmental variable of the system, or inside MATLAB by using the following command:

```
setenv('ROBOCUP_REPO_PATH','REPOSITORY PATH ADDRESS')
```

The second argument is the address in which you have downloaded the Tech United repository.

- Install Tech United software
  After installing MATLAB you need to launch MATLAB as root:

```
robocup@devpcX:~$ sudo su
root@devpcX:/home/robocup# matlab
```

Then in MATLAB run the following .m files:

```
>> make_all_install
>> build_all
```

For further information you may contact members from Tech United team.

4 Advantages and Disadvantages Analysis

4.1 Advantages

Using TURTLEs has the following advantages:

- All information required for rule violation detection is processed and could be used to prepare an algorithm for referee decision making.
- The state of the game is extracted from 'inside' of the game.
- Easy to access to real-time data.
- Reliable hardware and software available.
- Easy interaction with experts (Tech United team).
- Able to represent a real robot soccer game.
- First step for a future implementation of an autonomous referee.

4.2 Disadvantages

In addition to the above advantages, using TURTLEs has some disadvantages:

- The information might be subjected to noise since localization during robot motion is distorted and field is highly symmetrical.
- The position of ball is estimated by several sources, thus a smart algorithm is required to merged the information.
- The source of the data is relatively single and processed, so the data may be biased.

5 Suggested Improvements

For subsequent project teams, the usability of the project can be improved by adding data sources (such as fixed cameras or drones) and optimizing the referee algorithm. The former requires more image processing, while the latter requires more task implementation.

References

[1] W. Houtman, C. M. Kengen, P. H. E. M. van Lith, R. H. J. ten Berge, J. J. Kon, K. J. Meessen, M. A. Haverlag, Y. G. M. Douven, F. B. F. Schoenmakers, D. J. H. Bruijnen, W. H. T. M. Aangenent, J. J. Olthuis, M. Dolatabadi, S. T. Kempers, M. C. W. Schouten, R. M. Beumer, W. J. P. Kuijpers, A. A. Kokkelmans, H. C. T. van de Loo, and M. J. G. van de Molengraft, "Tech united eindhoven middle-size league winner 2019," pp. 517–528, 2019.