

Judy 2022 Team Description Paper

Marina Neves Beppler Artur T. Coelho
Arthur Stocco S. e Silva Eduardo C. Neves
Gabriel Nascarella H. do Nascimento Luan Matheus T. Dalmazo
Yasmin de C. Fernandes

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Abstract. *The present document serves as the required Team Description Paper to be submitted for qualification in the 2022 Salão da Robótica competition.*

Judy is a LEGO Sumo robot, built entirely out of LEGO tools such as the Mindstorms EV3 brick and various LEGO Education kit pieces like sensors, motors and batteries. Judy's main differential is its MicroPython programming, along with the strategy selector interface that allows the selection to be done in real time. It has been developed by UFPR's robotics team, Equipe Yapira.

Its main line of research and study regards the use of alternative methods of programming to enhance the quality of its programs and strategies. This approach allows more accessibility to EV3 programming tools and in turn, makes more elaborate programs possible alternatives while also optimizing the robot's actions. In regards to possible development issues, it's interesting to note the slight overhead timing issue that makes the initial waiting time until the programs start very variable — while the ideal in a common LEGO Sumo match would be five seconds maximum. This issue has been overcome by team via the switching to a single selection program that contains all of Judy's strategies, plus a graphical interface for the selection itself.

In this study, the team aims to contribute to the LEGO robotics community by developing a way to use the MicroPython alternative programming, that allows the use of Python for robot strategies instead of the usual block-oriented one.

1 Introduction

Developed by UFPR's Equipe Yapira de Robótica Judy is a robot made entirely out of LEGO, belonging to the LEGO Sumo 1 kilogram category. Its most important feature is the Mindstorms EV3 brick that, along with a microSD card that boots EV3DEV — a Debian Linux-based operating system for LEGO MINDSTORMS compatible platforms — contains and manipulates its programming.

The programming itself is done in the Python programming language instead of the usual block-oriented kind.

Judy was designed to be a LEGO robot capable of raising and pushing its adversary off the arena with ease, seeking to catch its enemies off guard by catching them by the side. To do that, it uses a frontal ramp and an ultrasound sensor.

While this robot didn't leave anything to be desired in terms of construction, not being modified since circa 2020, the programming and strategies are in constant improvement to ensure Judy is in its best possible shape.

2 The mechanical construction

Since its initial idea, Judy's mechanical construction has always been focused on robustness and mass so the robot would be strong enough to push its adversaries out of the dojo. Its structure has suffered only minimal alterations since then, mostly for aesthetic reasons or for adjusting its mass to be up to regulation.

Like most LEGO sumo robots, Judy had its mechanical development done using various LEGO blocks and a EV3 controller block.

This robot was designed to be able to push and raise its enemies by catching them unawares on their sides. That can be done thanks to its frontal ramp and an also frontal ultrasound sensor, along with the robustness that has always been ingrained into Judy's design. This strategy has been incredibly effective against various opponents that didn't have a way of preventing this kind of attack and even less means to counter it. Its biggest difficulty comes from opponents with multiple angled ramps and sensors.

2.1 Construction challenges

With a somewhat tricky, but extremely durable structure, Judy can be considered the team's hardest robot. Out of a desire of keeping it the same, not many alterations have been made during its lifespan.

Judy's main problems have been related to mass issues. As a robot idealized to be able to push adversaries around the arena, it is essential that it has adequate weight to do so.

As previously stated, that weight issue was the cause of the minimal re-workings Judy has gone through in the past, each of them aiming for weight redistribution as a way to have the most optimized functioning possible.

In addition to them, there has been the occasional aesthetic change. Those alterations have no great influence in its functioning and so, are not mentioned individually.

3 The robot's programming

Judy's programming has been altered for the first time in 2019 and has been improved upon ever since. Judy has been a pioneer in the team's approach

to alternative programming, being the first robot to use the MicroPython and EV3DEV combo. This language presents one of the most objective and efficient methods of implementing the Python language in micro-controllers.

Most of LEGO Sumo robots have block-based programming, the default to EV3 bricks. This method works well for most robots, in a sense that its a programming mode that can be quickly and cleanly execute commands. It is, in general, a great help during strategy development, as it is a simplified way of giving the robot instructions. However, it is limiting in terms of functionality, not supporting certain kinds of logic that the team wanted to implement.

That being said, the conversion to MicroPython was the simplest way to achieve a more flexible way of programming strategies into Judy. In order to do that, a complete overhaul had to be executed, changing its operational system to EV3DEV, along with a microSD card configured with its new, Python based strategies and interface.

3.1 Overhead issues

This change, unfortunately came with a slight overhead issue in Judy's functioning. Python scripts in EV3DEV can take a long time to begin executing, taking a largely variable time to do so. In early testing, the program's initialization could either take five to nine seconds in delay or begin executing around five seconds in advance.

This kind of issue is unacceptable in the context of official sumo matches, as the ideal waiting time in the beginning of each fight is of five seconds. With that in mind, the way of thinking about Judy's strategies and program had to be rethought from scratch.

3.2 Graphical interface

On the context of optimizing Judy's start timing, a new program was developed for storing and displaying its many strategies. Named "*Seleção Geral*" — General Selection, in a loose translation — this program contains both the strategies instructions with a way to select them and a neat graphical interface that's printed simultaneously to the program's execution and must act as a guide of sorts through the multiple options.

This program has masterfully resolved the problems with overhead and the interface itself has greatly improved the understanding of each strategy as well as simplified the real-time selection.

4 Background

It's important to mention the LEGO sumo competition scenario in the country. As a team, Yapira has always striven to be aware of the current tendencies in the area and constantly improve our robots. All of that is done to ensure our creations have the best possible performance in every competition they have

participate in — always considering that most of Brazil’s competitions have adopted this fighting format.

In the LEGO sumo category, the team has two other robots: Gaitaço, built with a NXT base brick; and Corsinha, the newest addition to our team, one that uses a EV3 base brick along with the MicroPython programming, just like Judy. Every single one of our robots is designed with the intent of having the most creative mechanisms possible, ensuring varied manners of striking a victory.

Although Judy is not the team’s first nor newest LEGO member, it remains the sturdiest one. The team is very proud of its achievements.

5 The “Seleção Geral” program (Main Research)

As previously stated, in order to deal with initial issues with Judy’s starting time, its entire system had to go through a major reworking. The solution was a tricky part of the process and as a result, has become our main area of research in this project.

In order to counter Judy’s patchy timing, a new strategy program called “*Seleção Geral*” came to be. The change to the MicroPython was the principal factor that allowed it to come to fruition, allowing the team to compile all of her code into one easy to use interface.

This selector allows the current operator to choose between the robot’s right or left side, as well as one of the strategy variations for Judy’s specified side. Among them are strategies that involve searching for the opponent after taking its time roaming the arena in wide circles in a couple of different ways and ones that already open the fight with scanning for the adversary. All of them were idealized by considering the most efficient way a single sensor could be utilized by a robot.

To facilitate maintenance, edition and version control of the strategy’s coding, the team has been using Git repositories. All of it is also stored in a SD card that is inserted into Judy and used to boot up the EV3DEV operational system.

6 Judy’s main achievements

Since 2016, Judy has achieved a lot for the team. Her main conquests were the trophies it earned in several different competitions — precisely four of them.

In 2016, Judy won first place in the LEGO sumo category at the Salão da Robótica competition. Later, in 2019, it won second place in the same category and competition.

Also in 2016, the robot earned third place in the 12th edition of Robocore’s Winter Challenge.

Finally, in 2019, the robot has won first place in SRC (Summit de Robótica da Católica SC). As always, it was competing in the LEGO sumo category.

The team also considers Judy’s pioneering in the matter of use of MicroPython/EV3DEV to develop strategies, plus the strategies themselves to be a big

achievement. The use of those technologies in this robot have served as a base for the team's subsequent robots and as a reference or starting level of sorts for all our work in the LEGO sumo category. It has defined the technologies we use to this day.

7 Conclusions and future work

With the continued use and development of Judy, it was concluded that there are always ways to achieve a ideal solution, even if it may be a somewhat more complicated. It has proven that this kind of alteration can be a game-changer, allowing the use of new, more accessible technology in a already popular area — something that every robot of this category can benefit from.

In relation to future work, here's very little to improve upon. While it is always good to come up with new strategies or improve the ones that already exist, Judy's have been very efficient up until now. In the same vein, the robot's mechanical construction leaves nothing to be desired so there's no intentions on altering it.

References

1. EV3DEV. 2014. *EV3DEV Home*, <https://www.ev3dev.org/>.
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3. LEGO group. 2020. *Getting started with LEGO® MINDSTORMS Education EV3 MicroPython*, <https://pybricks.com/ev3-micropython/>.
4. Ralph Hempel et al. 2020. *python-ev3dev Documentation*, <https://buildmedia.readthedocs.org/media/pdf/python-ev3dev/latest/python-ev3dev.pdf>.

We use EV3, which has the Sitara AM1808 processor, and a 32-bit ARM9 core. Its operational system has been altered to EV3DEV.

Robot's Software Description

For our robot we are using the following software:

- Platform: EV3DEV, a Debian Linux-based operating system for LEGO MINDSTORMS compatible platforms.
- Face recognition: None.
- Object recognition: Ultrasonic sensor.

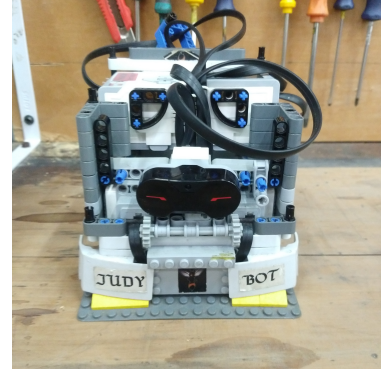


Fig. 1. Robot Judy

External Devices

Judy robot relies on the following external hardware:

- 1× Ultrasonic sensor

Robot's characteristics

- Dimensions: 14cm x 14cm.
- Weight: 828g.
- Traction type: Motors (2);
- Number of sensors: 1.