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Development of a pizza delivery robot

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Introduction
The goal of the project is a creation of a self driving pizza delivery robot that can use its sensors to recognize intersections and analyse the map and obstacles on it to find the shortest path and make successful deliveries to the destination addresses.

Functionality
The drive begins when the robot recognises the light on the table. As soon as the light turns on, the code for finding delivery addresses is executed. The robot is programmed to always follow the line and execute instructions when it gets to an intersection. The map of the table is represented as a string, each character in which is an intersection on the table. For example: {F..x..}, in which the dot means that an intersection can be driven through, whereas 'x' means invalid intersection and it cannot be used for making a path to the destination address 'F'. The most important parts of a routing algorithm of the robot are two main procedures: Planner and Interpreter.

Planner
The robot performs the Breadth-First Search algorithm, analysing characters in the string to determine the shortest path to the delivery address. Each intersection is one element in the string and its position in it is its ID. The algorithm starts from inserting all the neighbouring intersections of the start position in the queue and saving their parent intersection in the array. Then it dequeues and analyses the elements one after another. If the dequeued element is a destination address 'F', the search stops, the path is built on the basis of the parent array and the algorithm returns 0. If the element is not a destination, then its neighbours are inserted in the queue and the search continues. At the end, if the path to 'F' was not found and there are not any elements left in the queue, the algorithm stops the search and returns 1, indicating that the route was not found. (Fig. 1)

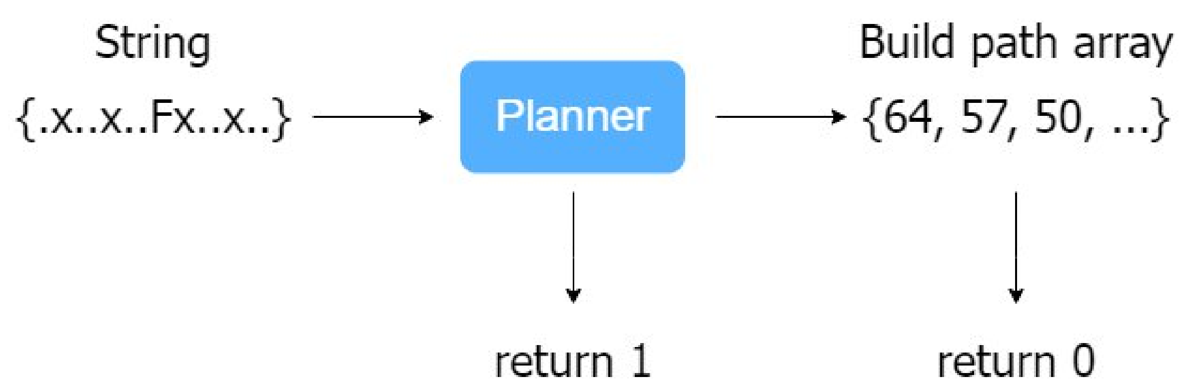

Fig. 1: A simplified diagram of the Planner working principle.

Interpreter
If the search was successful and the path to the destination was built, the instructions where to drive and which turns to take are still required. This is where the interpreter is needed. It analyses every element and its follower in the path array. Depending on the direction which the robot is facing and the elements of the array, it creates a new character array called 'instructions', which can contain the following elements: 'R', 'L', 'F' and 'U' which stand for right turn, left turn, forward movement and U-turn respectively. After the delivery the robot needs to get the instructions to get back to the starting position. This is achieved by reversing the instructions array and changing all left turns to right turns and vice versa. (Fig. 2)

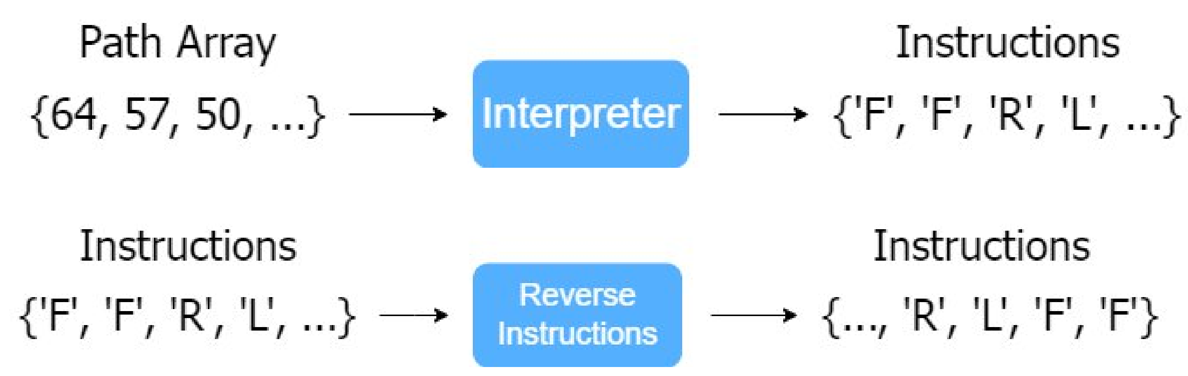

Fig. 2: A simplified diagram showing the working principle of the Interpreter and the method for reversing the instructions array.

Hardware
The robot consists of LEGO bricks and sensors that enable it to drive and make successful deliveries. The most significant parts of the robot are: the micro-controller board, two LEGO Power Functions XL-Motors for two wheels in which the gear ratio is approximately 1:2, two infrared sensors for distinguishing black and white colours, one light sensor, one touch sensor, a cargo bay with one LEGO Power Functions 88003 L-Motor for opening the gate, an acoustic alert system with a LEGO Power Functions 8883 M-Motor and the framework that holds all the parts together. (Fig. 3)

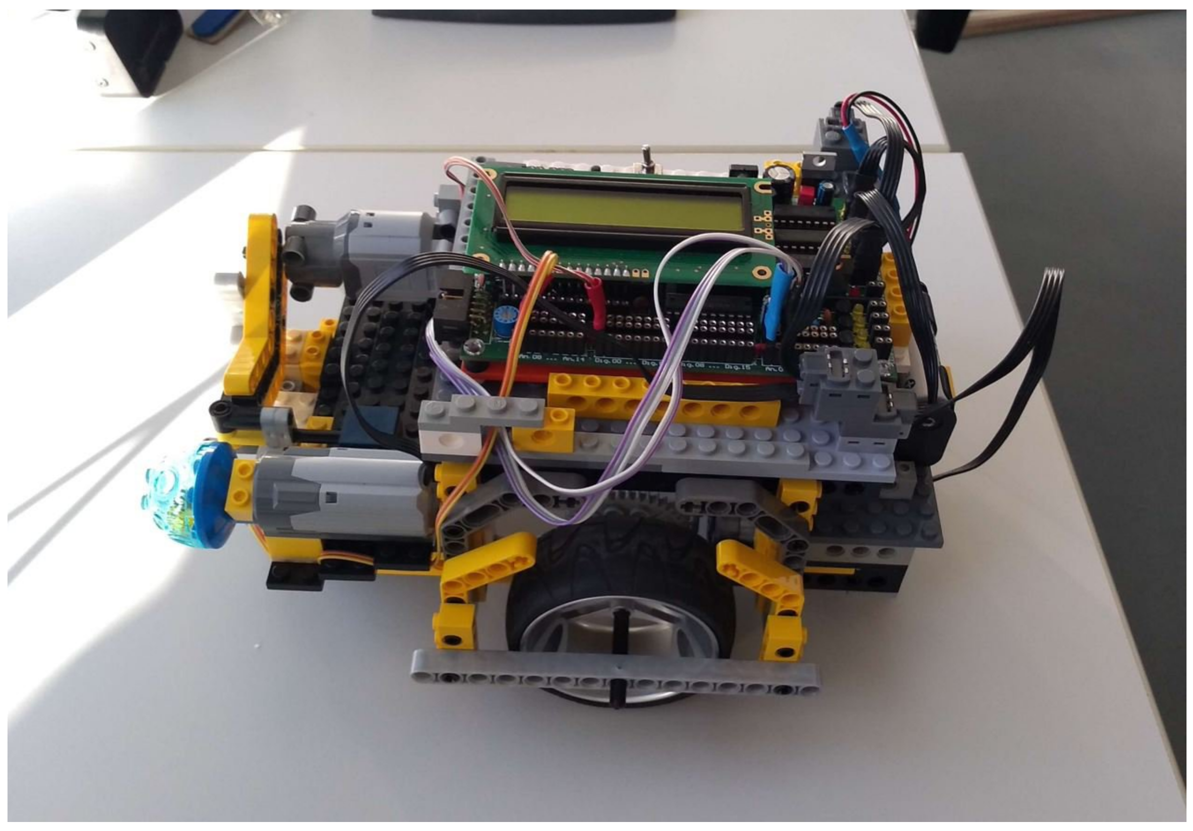

Fig. 3: The robot. (Side view)

Summary
The combination of the robot's software and hardware enables it to drive and perform its tasks correctly. The biggest achievement of the project was the development of an automated search algorithm and its fusion with the movement functions of the robot. Both the programming process and the overall development of the robot made it clear how different parts of the software and hardware work together and make it possible to perform non-trivial tasks such as automated deliveries.