RoboCup Junior Rescue Line 2024 Team Description Paper

June 19, 2024

Steven Wei, Allen Liang, Michael Zhang, Max Chen

Team KAVOSH

Table of Contents

Introduction to Team Members

The robotics team, KAVOSH, comprises four dedicated members, each bringing unique skills and experiences to the team.

Steven Wei, with three years of robotics experience, with 2 from BEETA and 1 from X Educations, specializes in modeling and mechanical engineering. Proficient in languages such as Arduino, Python, and C Plus, Steven has worked with softwares like Fusion 360, SketchUp, and SolidWorks. His expertise extends from coding and modeling to mechanical engineering as he has experience with repairing various electronic boards and wiring. Steven Wei constructed and modeled the main structure of the robot, along with various additional components such as the casing, rotor, ball bearing enclosure, and wheel assemblies.

Allen Liang, with an extraordinary six years of robotics experience, mostly in China, excels in coding with Arduino, Python, and block-based programming. His proficient modeling skills with Fusion 360 and SolidWorks, combined with hands-on mechanical engineering experience, have led to the successful creation of his own robots. Allen Liang designed both the gripper mechanism and its protective casing.

Michael Zhang contributes his coding prowess in Python, Arduino, and Java, along with developing understanding in Fusion 360. His mechanical background includes working with computer boards, showing his firm understanding of several robotic systems. Michael Zhang contributes to the programming aspect of the robot, focusing primarily on crucial functionalities such as the locomotion, rotation, LCD display integration, Ultrasonic Sensor interaction, side sensor management, color detection, among other key components.

Max Chen brings coding expertise in Python and Arduino, along with modeling skills in Fusion 360. With several years of coding experience, he has contributed greatly to the automatic proportion of the KAVOSH robot. While his mechanical engineering experience is still developing, Max's strong foundation in coding has made him a valuable asset on the team. Max has contributed to another aspect of coding, focusing on significant functionalities of the robot such as programming the Evacuation Zone for the Rescue Line. For the Evacuation Zone, he has written code for controlling the gripper and the arm, managing the box and rotor rotation, servo operations, and other essential tasks.

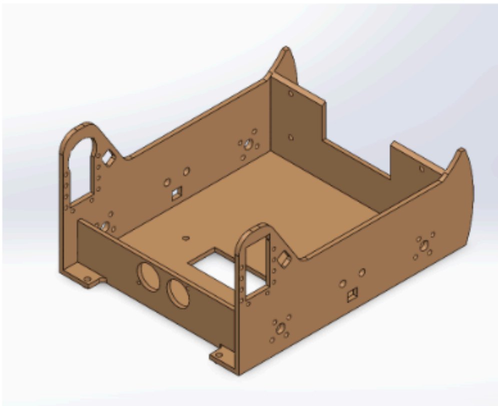
Introduction: Team KAVOSH

Team Kavosh has built a reputation over its 14-year history in the realm of robotics competitions, consistently achieving remarkable success on the global stage. Their achievements include numerous world first places in the individual sections of international events such as RoboCup Australia 2019, RoboCup Canada 2017, and RoboCup Japan 2017, where their advanced rescue league performances set benchmarks in robotic innovation. Additionally, their achievements extend to securing world second place in the individual team section at RoboCup Germany 2016, and claiming top honors in the super team section at RoboCup China 2015. The team's success is further shown by their technical achievements, winning first place in the technical sections of RoboCup Brazil 2014 and RoboCup Netherlands 2013, with valuable support from institutions like the Red Crescent Society of Tehran Province and Bank Melli Iran. Now, after 11 years since their last participation in RoboCup, Kavosh returns with a fresh lineup of members, aiming at achieving first at RoboCup Netherlands 2024.

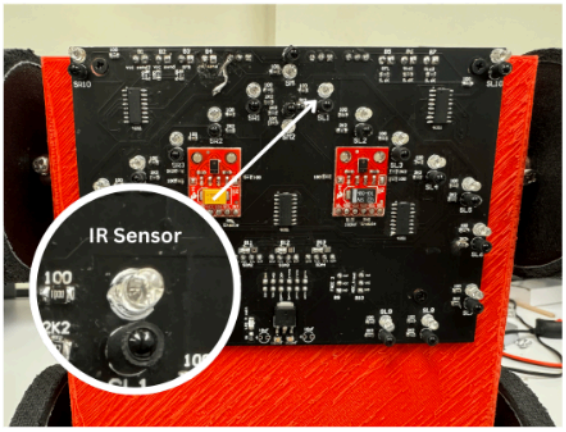
The current team draws substantial inspiration from the KAVOSH robot of 2018. While they have not replicated it outright, team members extensively researched the 2018 KAVOSH robot, studying its innovations, designs, and capabilities. This thorough examination has led them to design various components that bear similarities to those found in the 2018 model. Through this process, they aim to integrate and adapt the proven strategies and technological advancements that contributed to the success of the 2018 KAVOSH robot, ensuring their own designs are informed by past achievements while incorporating approaches suited to their current objectives and challenges.

Project Planning: Overall Project Planning

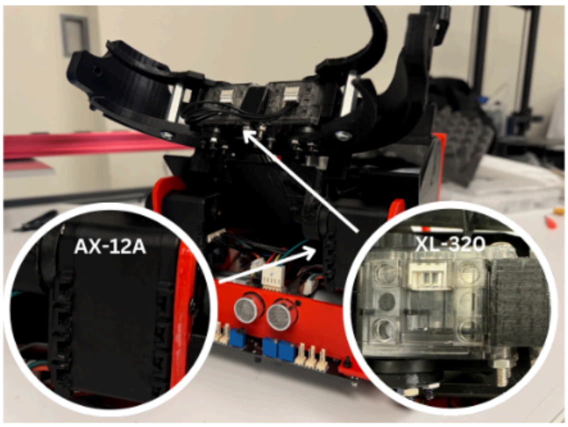
In pursuit of first place in the RoboCup Junior Rescue Line 2024 robotics competition in Eindhoven, Netherlands, Team KAVOSH has set a comprehensive objective aimed at designing and constructing a highly efficient and versatile robotic system capable of navigating precisely and efficiently through the rescue line course. This objective necessitates careful planning and execution considering various constraints such as time limitations, physical constraints, and following competition rules. The team's overall project plan encircles several key goals, each strategically designed to ensure the successful realization of our objective. Beginning with the design and prototyping phase, scheduled for around 4 months (beginning approximately in January of 2024), our team, led by Steven Wei and Allen Liang, will develop initial robot design concepts and create prototype parts for testing. During the mechanical construction phase, Steven Wei and Allen Liang will lead the construction of the physical structure of the robot based on the finalized design specifications using Fusion 360 and SolidWorks, which will later be printed out using a 3-Dimensional printer. This will be followed by the electronic integration phase, where Allen Liang and Michael Zhang will add electronic components, including sensors and microcontrollers, microswitches, servos, and others, into the robot's whole body. As Team KAVOSH progresses to the software development phase, Michael Zhang and Max Chen will take charge of developing and debugging the software algorithms significant for autonomous navigation, obstacle detection, and Evacuation Zone management. Finally, during the testing and optimization phase, scheduled for the last few months before the competition, the entire team will conduct several rigorous tests of the robot's functionality under simulated competition considerations and tracks.



Team KAVOSH carefully integrated a range of components to achieve the objectives in the RoboCup Junior Rescue Line 2024 robotics competition. Each component was carefully selected and configured to satisfy the specific requirements Team KAVOSH developed, ensuring optimal performance and efficiency to complete the necessary tasks on the competition course. Starting with the line following and obstacle detection, the Infrared 3 Millimeter 940 Nanometer Transmitter and Receiver play a significant role. By emitting infrared light and detecting its reflection, these sensors can distinguish between black lines and silver surfaces. To clarify, when the infrared sensors register a voltage exceeding 2.5 V, it indicates that the front sensors are positioned on a black line. Additionally, there's another set of sensors in the front designed to detect silver, for which the resistance can be adjusted using a utilized potentiometer.

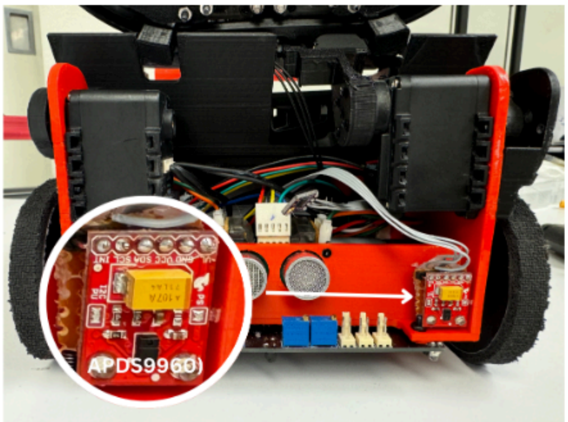


The Dynamixel AX-12A servos are utilized for various tasks, including rotating objects (silver and black balls) and controlling the movement of the gripper mechanism. With the ability to rotate up to 300 degrees, these servos provide the necessary precision and flexibility required for manipulating objects within the Evacuation Zone. Inside the enclosure, the robot's rotational component uses an AX-12A servo linked to a rotor, distinguishing between conductive and non-conductive balls. Tin foil wrapped around tin wires are attached to the moving gripper to detect ball conductivity, sorting them into designated spots in the box. When a ball, whether silver or black, is detected and placed into the box, the EEPROM (code memory) will record its position in the rotor. This information will be used later when the robot drops the ball into the designated box.

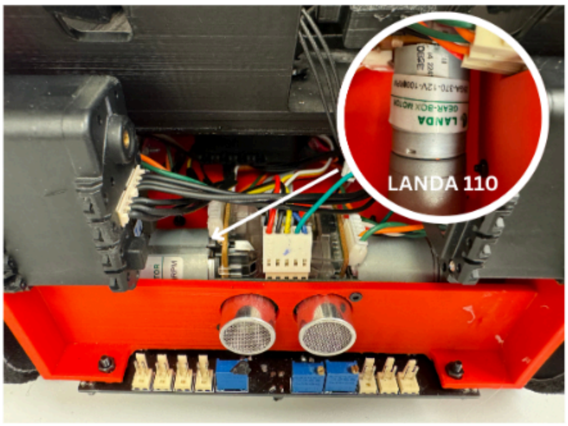


If the color recognition sensors (APDS9960) detect green or red, the robot halts and the rotor within the box turns to the specific ball, raising the box to release it. When the robot approaches the green box, the rotor rotates so that the silver ball (representing a live victim), will be in the open, ready to be released.

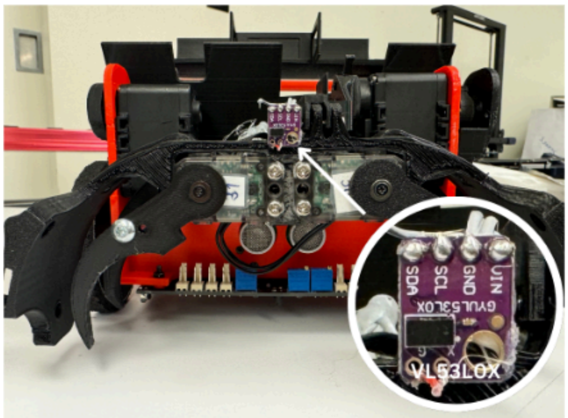
Another servo, connected to the box itself, raises it 90 degrees to release the balls targeted by the first servo. Same goes for the red box, but instead of the silver ball, it is the black ball (representing a dead victim). The third servo, attached to the arm, remains at a neutral 180-degree angle, but when the infrared sensors on the Infrared 3MM 940NM line follower board detect silver, the AX-12 motor rotates 180 degrees downward. The arc installed on the top of the box prevents unintended balls from falling, holding the other three balls in place with its ceiling-like design.



For the wheel, the LANDA 110 RPM (revolution per minute) servos are responsible for controlling the movement, enabling the robot to navigate and maneuver through the court with ease. The SRF05 Ultrasonic Sensor serves the only purpose of calculating distances from walls or obstacles. Only the Ultrasonic Sensor is present in the front, primarily for obstacle avoidance preceding the Evacuation Zone. In addition to the Ultrasonic Sensors, there are three VL53L0X sensors, with two encased in white plastic housings on the right and left sides of the robot, while the third is mounted on the arm, serving the same obstacle detection function as the SRF05 Ultrasonic Sensor.



The VL53L0X also functions as a sensor to detect the colored boxes in the evacuation zone. The walls of the evacuation zone are tall enough that the robot will recognize contact with them through the sensor. However, when the robot encounters a box, the VL53L0X sensor will not detect any contact. At this point, the APDS9960 color sensor will identify the box's color, and the VL53L0X will verify the absence of contact. Once the box is identified and verified, the AX-12A motor, which controls the rotor, will rotate to position the ball corresponding to the specific color of the box. Currently, the compass, installed on top of the handle on the back of the robot, remains inactive, as the code already integrates compass functionality, although it may be utilized in future projects. Microswitches are employed on the arm to detect if the robot impacts a wall. In the ATmega 128 code they personally coded, if both



microswitches detect contact with the wall, the robot is programmed to reverse and turn either right or left by 90 degrees.

In terms of communication, each component of the robot interacts with each other through a combination of serials (UART), I2C, parallel communication, and multiplexers. For example, the LANDA 110 RPM plus encoder motors communicate with the driver on the main circuit which in turn communicates with the brain of the robot. Servos communicate through serial (UART) with the brain, while color sensors and distance sensors communicate through I2C, allowing for data exchange and coordination of actions. Ultrasonic Sensors utilize parallel communication to calculate distances from obstacles, providing valuable information for obstacle avoidance. Moreover, infrared sensors are connected to the brain through multiplexers, enabling efficient data processing and decision making.

All of these components were specially chosen by Team KAVOSH members through extensive testing and insights gained from past competitions. During the testing phase, various components were integrated into the same robot body to evaluate their speed, precision, and durability. This thorough testing process led Team KAVOSH to select the optimal components listed above.

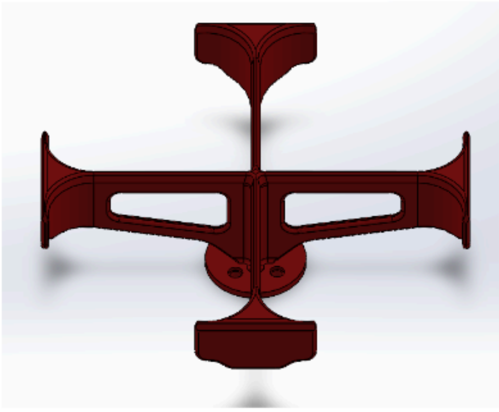
Hardware: Introduction

The robot's hardware design is built around a sturdy frame equipped with wheels, providing both stability and mobility.

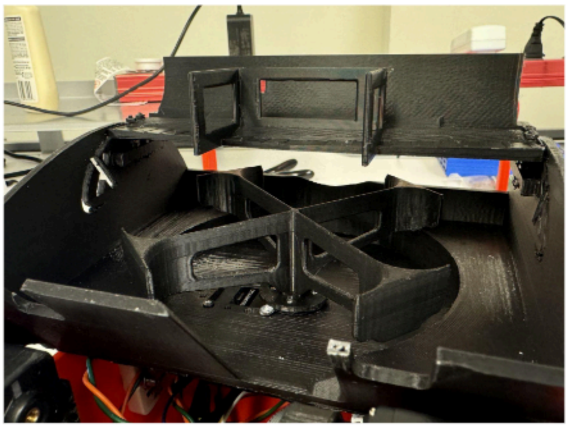
At the heart of its functionality lies an array of sensors and actuators. Infrared sensors, strategically positioned, facilitate precise line following and surface differentiation, crucial for navigation tasks. Ultrasonic Sensors serve to determine distances from obstacles, helping navigate through the environment and the rough foundation of the Evacuation Zone. Additionally, VL53L0X distance sensors offer supplementary support in obstacle detection. Microswitches are utilized in the robot's arm in order to detect collisions with walls or unexpected barriers, prompting immediate corrective actions such as moving backwards or turning. Actuation is achieved through a combination of Dynamixel AX-12A and XL-320 servos, each assigned specific roles. The AX-12A servos are used to function rotor rotation, box lifting, and arm manipulation, ensuring efficient execution of complex maneuvers. Meanwhile, XL-320 servos manage the task of gripping balls within the Evacuation Zone.

Together, these components combined construct a robust hardware framework capable of meeting the demands of challenging environments and tasks in RoboCup Junior Rescue Line 2024.

For Team KAVOSH's mechanical engineering, they employed a combination of Fusion360 and SolidWorks to design our robot comprehensively. This included

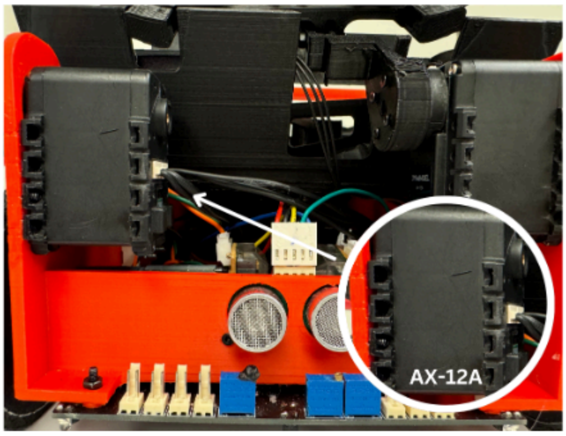


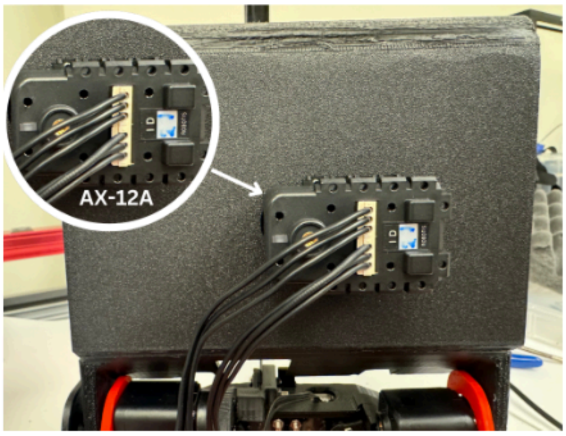
developing the main structure, the body, and various subassemblies such as the handle, wheels, box, and rotor. To transform these designs into tangible components, they used the AnkerMaker 3D Printer. The main structure, which forms the robot's body, features specific designs and holes for screws, machinery, and servos, serving as the foundation of the robot. The handle, located on the back and secured with 2 mm screws, facilitates efficient portability of the robot. The box, a crucial component for holding balls during the Evacuation Zone phase, incorporates a specially designed rotor to place specific material balls into designated slots. This box is tailored to fit a ball bearing on the left side of the robot, allowing the Dynamixel AX-12A motors on the right side to lift the entire box structure with additional support from the ball bearing. Finally, the wheels integrate the robot's design cohesively. Each wheel is surrounded with Team KAVOSH's name and covered with a special type of mouse pad cloth, providing the necessary grip for the robot to overcome obstacles such as bridges and seesaws.



Team KAVOSH's robot is equipped with a variety of sensors, motors, and servos, specifically designed to execute the tasks required for the Rescue Line challenge.

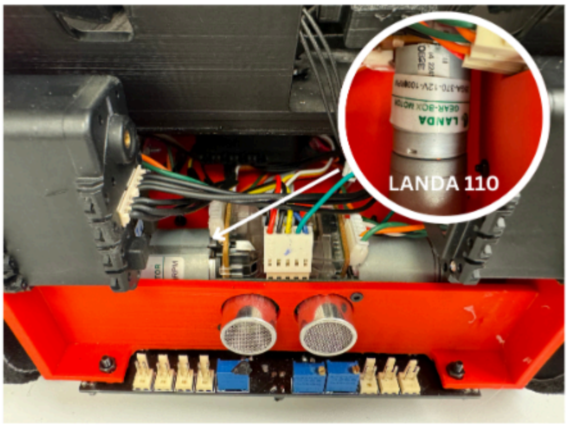
The primary components for the robot's arm movement and the rotor within the box are the Dynamixel AX-12A servos. Team KAVOSH selected the AX-12A servos over conventional alternatives like the Diymore 35 kg Digital Servo due to their lightweight design and enhanced flexibility. The AX-12A servos offer a 180° rotation, which is ideal for the robot's box and arm, as these components only require a 180° turn to perform their tasks effectively. Additionally, the AX-12A servos are known for their high speed, which is crucial for the time-sensitive operations in the Evacuation Zone like grabbing balls and dropping them. During the Local RoboCup Competition in Montreal, the team initially used a very fast servo. However, in round 2 of the first day's competition, the excessive speed of the rotor caused one of the four balls in the box to pop out, leading to a significant point deduction and damage to the rotor. This incident highlighted the need for a more balanced approach to speed and control. The decision to switch to the AX-12A servos was made collectively by Team KAVOSH, recognizing that this change would require substantial modifications to the robot's code and design. Despite these challenges, the transition proved beneficial. The robot became more precise and efficient, demonstrating improved performance in Rescue Line competition.



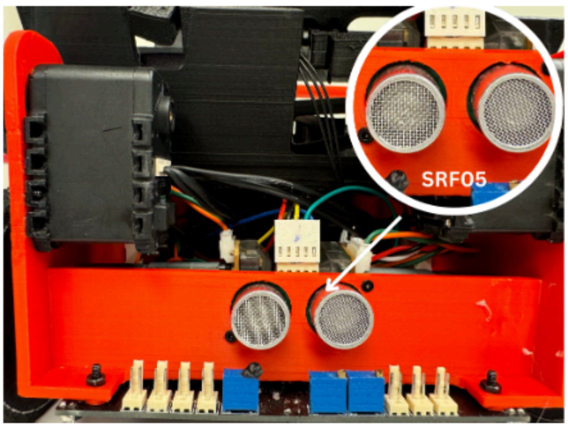


Another servo utilized in Team KAVOSH's robot is the Dynamixel XL-320. This compact servo is primarily used for the robot's gripper, a crucial component designed to carry and drop the ball into the rotor-equipped box. Despite its small size, the XL-320 is notably powerful, offering a stall torque of 4.0 kg·cm at 7.4V. The servo is also highly efficient. Although the servo can only rTeam KAVOSH ingeniously connected the top and bottom grippers using specific metal rods of a particular length to allow the robot's gripper to achieve precise and reliable performance despite rotating on one side.

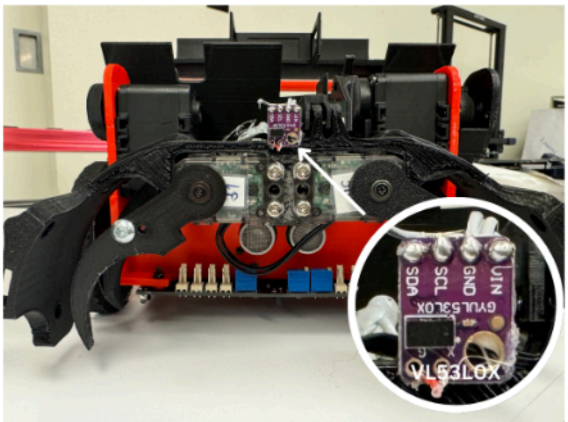
For a robot to function properly, it must have a servo that moves the robot's overall structure. The wheels and their motors are crucial components, providing the mobility needed to bring the robot to life. Team KAVOSH's robot uses the LANDA 110 RPM (revolutions per minute) motor, a high-tech, powerful, and compact motor connected to the robot's wheels. This motor is one of the most advanced on the market, offering 2.4 watts of power, which is sufficient to move the robot, which weighs a little over 5 kilograms, over obstacles like seesaws and ramps. The wheels attached to the LANDA 110 RPM motor are specially designed to ensure stability and performance. They use screws to securely fasten to the motor's D-shaped shaft, creating a permanent and robust connection that prevents the wheels from detaching during competition. Additionally, the wheels are covered with a unique grip material made from mousepads. Team KAVOSH tested various materials, including rubber, plastic, and 3D-printed linings, and concluded that mouse pad material offers the best grip for navigating the Rescue Line. This grip is particularly effective for overcoming obstacles like ramps, where maintaining traction is critical to prevent sliding.



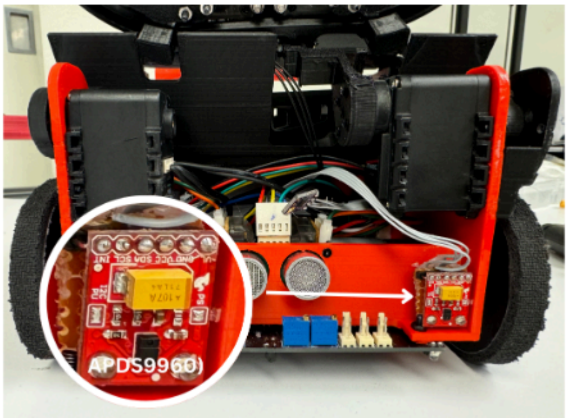
Team KAVOSH equipped their robot with two primary sensors, one of which is the SRF05 Ultrasonic Sensor. This sensor is essential for detecting the distance between the robot and any obstacles on the Rescue Line. The SRF05 Ultrasonic Sensor operates by emitting sound waves and measuring the time it takes for the echo to return, thus determining the proximity of an object. When the sensor identifies an obstacle within its field of view (FOV) that exceeds a certain size, it sends signals to the robot's control system. The control system then processes this information and initiates a series of precise maneuvers. Specifically, the robot is programmed to move backward for 2 seconds to create a safe distance from the obstacle. After retreating, the robot executes a turn with a specified radius, carefully calculated to navigate around the obstacle and continue along the Rescue Line.



The second sensor employed is the VL53L0X sensor, which is specifically installed for use in the Evacuation Zone. The VL53L0X sensor, also known as the DollaTek M5 Official ToF Unit VL53L0X Time-of-Flight (ToF) Range Sensor, is a distance measuring module designed for precise and accurate distance measurement. Utilizing Time-of-Flight technology, the VL53L0X sensor emits an infrared laser beam and measures the time it takes for the beam to reflect back from an object, allowing it to calculate distances up to 2 meters with millimeter accuracy. These sensors are mounted on opposite sides of the robot's structural body. During obstacle avoidance maneuvers, the VL53L0X calculates the distance between the robot and obstacles as it executes turns. In the Evacuation Zone scenario, the VL53L0X serves dual purposes: determining the distance between the robot and walls, and detecting any balls in proximity that other sensors may have missed. When the robot makes contact with a wall, the VL53L0X identifies which side detected the obstruction and directs the robot to turn away from that side to prevent further contact. Apart from the two sensors positioned on opposite sides of the robot's body, there is an additional VL53L0X sensor mounted on the robot's arm without the protective plastic casing found on the body-mounted sensors. This sensor serves to detect obstacles directly in front of the robot within the evacuation zone.

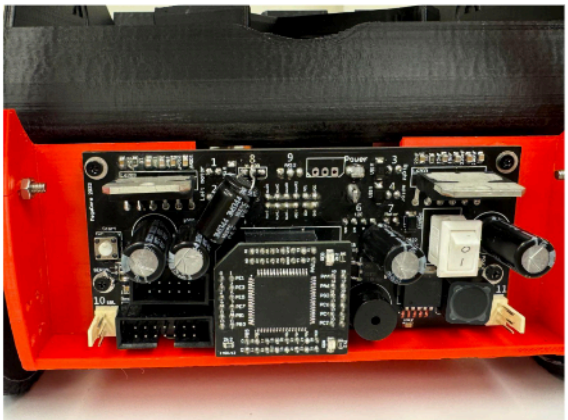


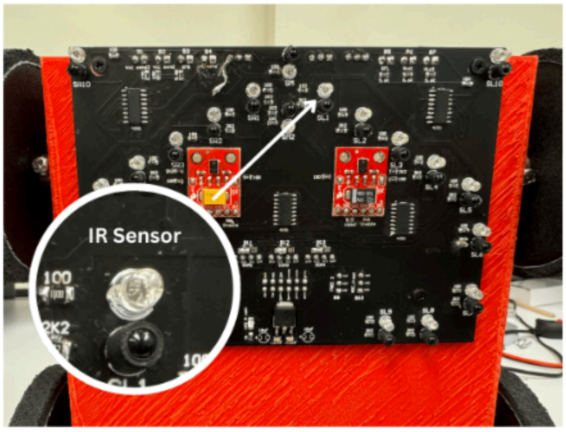
The VL53L0X also functions as a sensor to detect the colored boxes in the evacuation zone. The walls of the evacuation zone are tall enough that the robot will recognize contact with them through the sensor. However, when the robot encounters a box, the VL53L0X sensor will not detect any contact. At this point, the APDS9960 color sensor will identify the box's color, and the VL53L0X will verify the absence of contact. Once the box is identified and verified, the AX-12A motor, which controls the rotor, will rotate to position the ball corresponding to the specific color of the box. Before 2023, Team KAVOSH initially opted for two SRF05 Ultrasonic Sensors over VL53L0X sensors due to their familiarity and ease of use. However, upon discovering the superior precision offered by the VL53L0X sensors, Team KAVOSH decided to revise their strategy and adopt this advanced sensor instead. Upon testing both types, it became clear that the VL53L0X sensors excelled not only in detection accuracy but also in precise distance measurement capabilities compared to the Ultrasonic Sensors.



The APDS9960 is a digital RGB, ambient light, proximity, and gesture sensor. It integrates multiple functions into a single compact module, making it suitable for applications where gesture recognition, ambient light sensing, color sensing, and proximity detection are required. Team KAVOSH's robot utilizes the APDS9960 sensor to identify the color of boxes within the Evacuation Zone. When the APDS9960 sensor approaches an object or wall, it accurately detects its color and transmits this information to the motherboard. For instance, if the sensor identifies green, it signals the robot to direct the rotor towards the corresponding colored ball for placement into the box. Since the team opted not to include a camera in their robot design, the APDS9960 provides the most effective method for color detection in the Evacuation Zone. Additionally, if the APDS9960 detects red before dropping the two green balls, it prompts the robot to prioritize locating and interacting with the green box first.

The ATmega 128 is a microcontroller chip. It belongs to the AVR family of microcontrollers and is based on an enhanced RISC (Reduced Instruction Set Computing) architecture. In Team KAVOSH's robot, the ATmega 128 serves as the central processing unit, often referred to as the motherboard. Positioned at the rear of the robot, it is shielded by a custom-designed 3D-printed enclosure to safeguard it from potential contact with external objects. This component functions as the core control unit of our robot, housing and executing all programmed code. The ATmega 128 translates these instructions into commands that direct the robot's actions in various scenarios, ensuring precise and responsive operation.





The Infrared 3mm 940nm transmitter and receiver pair is used for transmitting and detecting infrared signals. It operates at a wavelength of 940 nanometers, enabling wireless communication and proximity sensing in devices such as remote controls and sensors. This component is employed for line following in their robot. It utilizes infrared sensors to accurately track and follow lines with precision. Not only this, but this is also used to detect the silver entrance to the Evacuation Zone, where it will sense the reflectiveness of the material.

The Bosli-po 11.1V battery is a type of lithium-polymer (LiPo) battery commonly used in various electronic devices and robotics projects. It provides a nominal voltage of 11.1 volts, making it suitable for applications requiring a stable and reliable power source. This serves as the primary power source for Team KAVOSH's robot, essential for powering the entire system. Chosen for its compact size, high voltage output, and extended battery life, this battery outperforms conventional options. It plays a crucial role in ensuring the robot's endurance during long competitions.

SoftWare

Team KAVOSH employs Arduino as the primary software platform for their robot, leveraging its intuitive interface and strong community support. The software integrates a range of functionalities crucial for robotics, including interfacing with sensors like ultrasonic and sensors for precise distance measurement and obstacle detection. Control algorithms manage motor function for mobility and servo motors for precise manipulations. Navigation algorithms enable the robot to autonomously navigate obstacles, while task-specific logic directs actions like object retrieval and placement in competitive scenarios. This software framework ensures efficient communication and coordination among the robot's components, enabling it to perform tasks accurately and reliably in various competition challenges.

Team KAVOSH structures their Arduino code to ensure the efficient and reliable operation of their robot.

The code begins with the setup function, where initializations are performed, including configuring sensor interfaces, setting communication protocols such as Serial communication for debugging and control, and initializing variables essential for sensor calibration and motor control. The main structure revolves around the loop function, which executes continuously, driving the core logic of the robot. Within this loop, sensor inputs are read and processed to gather real-time data on the robot's environment. Decision-making algorithms, carefully crafted by the team, interpret this data to determine the robot's actions, such as navigating around obstacles using data from sensors and ultrasonics, both crucial for precise distance measurements and obstacle avoidance strategies. Motor control routines manage the movements powered by motors, ensuring the robot navigates smoothly and performs tasks accurately in dynamic environments. Functions are structured modularly, encapsulating specific tasks such as sensor data interpretation, motor control algorithms, and communication protocols, fostering code reusability and ease of maintenance. Error handling mechanisms are integrated to anticipate and manage unexpected scenarios, enhancing the robot's robustness during operation. Throughout development, debugging tools like serial print statements aid in monitoring program execution and troubleshooting, refining the code for optimal performance.

This structured approach not only enhances the efficiency and reliability of Team KAVOSH's robot but also underscores their commitment to precision engineering in competitive robotics scenarios.

During the final stages of completing their robot, Team KAVOSH encountered a significant challenge with the gripper's ability to reliably drop the ball into the designated space within the rotor. Through several tests, it became apparent that the ball's placement was inconsistent, often falling into unintended spaces due to chance rather than precision. This variability posed a serious concern, potentially complicating the identification of balls within the rotor by the EEPROM system. To address this issue under time constraints, the team ingeniously devised a solution using plastic barriers around each designated space. These barriers were strategically placed to stabilize the ball upon dropping, preventing unintended movements and ensuring accurate placement. Given the imminent RoboCup Local Montreal Competition, this makeshift solution was necessary as there was insufficient time to develop and implement a completely new design. This adaptation underscored Team KAVOSH's resourcefulness and commitment to resolving challenges swiftly and effectively in competitive robotics.

Testing played a pivotal role in the timeline of building the robot and constituted one of the lengthiest phases. It was essential not only for verifying the robot's functionality but also for identifying areas where components could be enhanced. Once Team KAVOSH finished assembling the robot with its various components, they constructed a dedicated Rescue Line field complete with an Evacuation Zone within their facility. This setup enabled them to conduct thorough tests under varying environmental conditions and challenges.

During the testing phase, Team KAVOSH focused on evaluating two critical aspects: the speed of line following and the efficiency in collecting all the balls. Despite consistently completing the entire course ahead of schedule during timed runs, the team faced challenges due to their field being significantly smaller than the official RoboCup course. This necessitated estimating the robot's performance in a larger arena.

Within the Evacuation Zone, numerous tests were conducted to simulate various scenarios, including placing obstacles such as wooden chopsticks and obstacles at different positions within the zone. These tests demonstrated the robot's adeptness in avoiding obstacles and accomplishing required tasks successfully.

A crucial test involved evaluating the robot's turning capability within the Evacuation Zone. Initially programmed with ATmega 128, the robot utilized side sensors to detect and avoid walls, preventing collisions. However, during testing, this approach encountered setbacks, notably failures in sensor response and unexpected behaviors upon contact with colored boxes. In some instances, the robot entered a 15-second loop before dropping balls, while in others, it turned without completing the task. These issues, attributed mainly to coding nuances and sensor placement, were swiftly addressed through iterative adjustments and refinements.

Another significant challenge emerged when the robot failed to resume its sweeping motion after colliding with walls or encountering randomly placed colored boxes. This deviation from the intended path disrupted efficiency, as the robot occasionally reverted to random movements instead of continuing its systematic search for balls. To rectify this issue, additional coding modifications were implemented to ensure the robot maintained its sweeping trajectory despite obstacles encountered during operation. These adjustments underscored Team KAVOSH's commitment to refining their robot's performance through testing and iterative software development, ultimately enhancing its effectiveness in competitive environments.

Performance Evaluation

Team KAVOSH evaluated their robot's performance against a range of competition challenges, focusing on key criteria such as speed, accuracy, and reliability. During timed runs on their smaller-scale field, the robot consistently completed the course ahead of schedule, showcasing its agility and efficiency in line following and ball retrieval tasks. However, the team recognized the challenge of translating these results to a larger, official RoboCup course size, necessitating careful estimation and adjustment of their strategies and algorithms.

In the Evacuation Zone, where precision and obstacle avoidance are crucial, the robot underwent extensive testing scenarios. These tests included simulating obstacles like wooden chopsticks and varied placements within the zone to assess the robot's ability to navigate and complete tasks without errors. The robot demonstrated adeptness in avoiding obstacles and accurately performing tasks, highlighting its robust design and sensor integration.

Testing procedures were comprehensive and systematic, encompassing various aspects of the robot's capabilities. Initially, Team KAVOSH conducted controlled tests on their custom-built field to evaluate basic functionalities such as sensor accuracy and motor control. These tests provided foundational data on the robot's performance metrics and helped identify initial areas for improvement.

As testing progressed, more complex scenarios were introduced to simulate competition conditions realistically. This included timed runs to assess speed and efficiency, obstacle placement tests in the Evacuation Zone to evaluate navigation algorithms, and repeated trials to ensure consistency and reliability across different environments. Each test was documented, recording sensor readings, motor responses, and overall task completion rates.

Test results were analyzed methodically to pinpoint strengths and weaknesses in the robot's performance. Data collected during testing, such as time taken to complete tasks, accuracy in obstacle detection, and reliability in task execution, were scrutinized to identify patterns and areas needing improvement. Team KAVOSH employed statistical analysis and qualitative assessments to derive meaningful insights from the data.

Based on these analyses, iterative development cycles were initiated to address identified issues and enhance the robot's capabilities. For instance, coding adjustments were made to improve sensor responsiveness and refine navigation algorithms. Mechanical adjustments were also implemented to optimize gripper stability and ensure consistent ball handling during competitions.

Through rigorous testing and analysis, Team KAVOSH significantly enhanced their robot's performance and readiness for competitive challenges through coding and designing. The process of testing, analyzing results, and implementing improvements not only strengthened the robot's technical capabilities but also enhanced the team's understanding of effective robotic design and operation. By focusing on precision, reliability, and adaptability, Team KAVOSH positioned their robot competitively, aiming to excel in the demanding environment of the RoboCup competition.

Conclusion

Team KAVOSH, a dedicated group of robotics enthusiasts comprising Steven Wei, Allen Liang, Michael Zhang, and Max Chen, has developed a robust robotic system aimed at excelling in the RoboCup Junior Rescue Line 2024 competition in Eindhoven, Netherlands. Each team member brings unique skills and experiences, contributing to different aspects of the project from mechanical design and electronic integration to software development.

Their project planning spans several critical phases, starting with design and prototyping under the leadership of Steven Wei and Allen Liang. This phase, beginning in January 2024, involves creating initial design concepts and producing prototype parts using Fusion 360 and SolidWorks. Subsequently, Steven Wei and Max Chen lead the mechanical construction phase, where they translate finalized designs into physical components using a 3D printer. Concurrently, Allen Liang and Michael Zhang handle electronic integration, incorporating sensors, microcontrollers, servos, and other components crucial for the robot's functionality.

The software development phase, led by Michael Zhang and Max Chen, focuses on coding algorithms for autonomous navigation, obstacle detection, and precise manipulation tasks within the Evacuation Zone. Throughout these phases, the entire team collaborates to conduct rigorous testing and optimization to ensure the robot performs reliably under simulated competition conditions.

In terms of hardware, Team KAVOSH's robot is built on a sturdy frame equipped with wheels for stability and mobility. It features an array of sensors including infrared, ultrasonic, and distance sensors like VL53L0X for precise obstacle detection and navigation. Actuation is managed through Dynamixel AX-12A and XL-320 servos, each assigned specific roles such as rotor rotation, box lifting, and ball manipulation within the Evacuation Zone.

Their software architecture leverages Arduino for its versatility and strong community support, integrating various functionalities crucial for robotics competitions. The code is structured with setup and loop functions to initialize components, process sensor inputs, and execute control algorithms for motor and servo operations. Modular functions ensure code reusability and ease of maintenance, with robust error handling mechanisms to enhance the robot's reliability during operation.

Throughout their development process, Team KAVOSH encountered challenges such as ensuring precise ball placement within the rotor during the Evacuation Zone task. Their innovative solution involved implementing plastic barriers around each designated space to stabilize dropped balls, demonstrating their resourcefulness in overcoming obstacles under time constraints.

Performance evaluation focused on speed, accuracy, and reliability across different competition challenges. The robot consistently demonstrated agility and efficiency in line following and ball retrieval tasks during testing on their custom-built field. However, translating these results to a larger competition arena posed challenges, requiring strategic adjustments and algorithm refinements.

In conclusion, Team KAVOSH's dedication to precision engineering and collaborative effort has positioned their robot competitively for the RoboCup Junior Rescue Line 2024 competition. Their systematic approach to design, integration, and software development, complemented by rigorous testing and iterative improvements, underscores their commitment to excellence in robotics.