Presentation of Team BalloBot

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Group members

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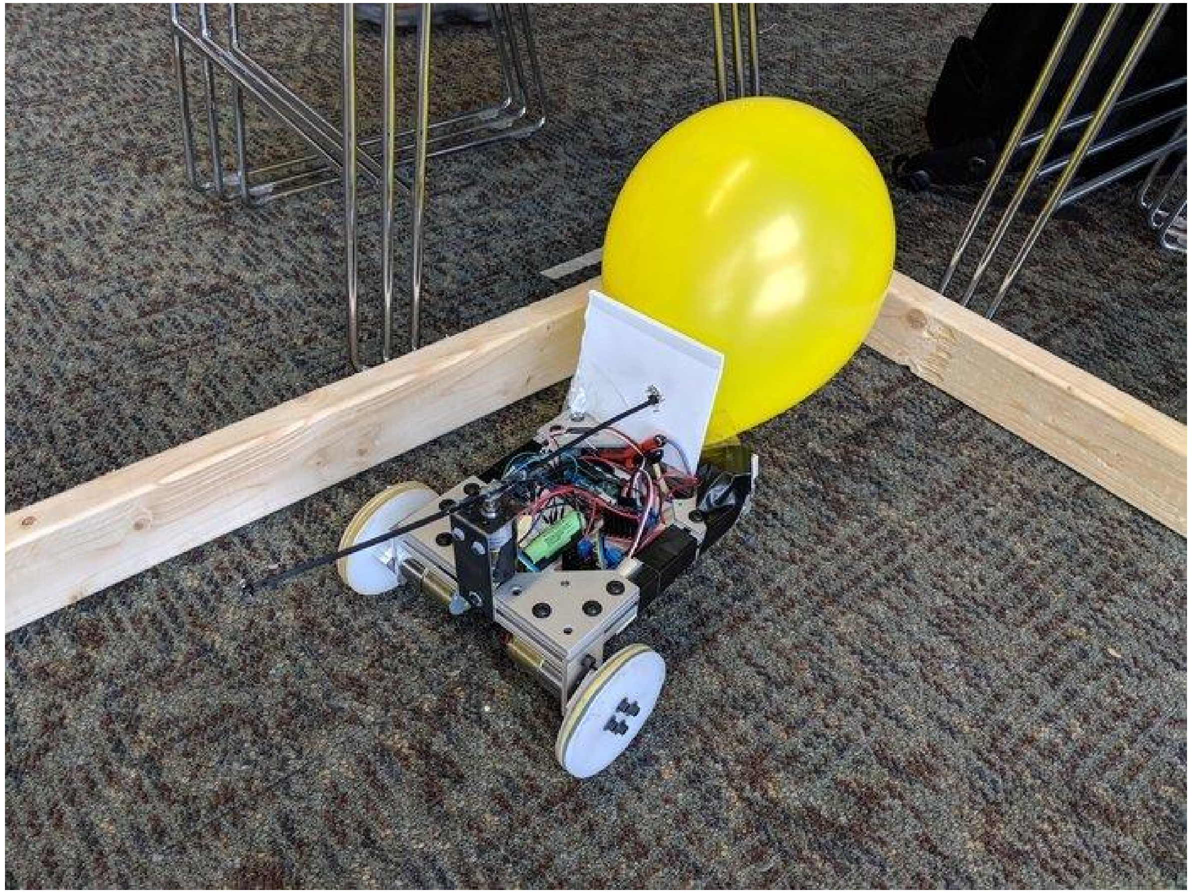
Project Objectives

Build a robot that can:

Scan the indoor environment;

Detect balloons of different colors;

Plan the path and move to balloons.



Novelty

Prototype of future applications of sports robots:

- **Autonomous decision-making and execution capabilities**
- The development of intelligent sports robots, such as football robots, demonstrates prototypes for future applications, in which robots have the ability to perform actions concurrently and are able to complete matches without human intervention.
- Reference 1

- **Personalised Training and Performance Enhancement**
- With an intelligent control system, including a separate design for decision-making and execution systems, the robot is able to mimic a human athlete and provide personalised training programmes to improve performance and training efficiency.
- Reference 2
- **Technology Integration and Challenge Response**
- The study points to future directions for improving robot performance, including enhancing execution capabilities, expanding sensory information, optimising decision-making processes, and enhancing environmental adaptability, providing a clear roadmap for future applications of sports robots

Sports technology systems that enhance the integrity, fairness and analysis of the game:

- **Multi-angle ball tracking and analysis**
- Using multi-camera system for ball tracking, it provides coaches with in-depth data analysis and assists referees in decision-making, while enriching the viewing experience of TV viewers and enhancing the integrity and fairness of the game.Reference 2

- **Vision-based motion analysis**
- Enhance the accuracy and efficiency of motion analysis through vision-based tracking systems, including tactical analysis and player tracking in training, as well as motion analysis in high-end training scenarios.Reference 3

Implementation Details

Capturing Images from the Network Camera

- The system starts by capturing real-time scene images through the network camera. This step initiates the entire image processing workflow, providing continuous visual data from the environment.
- The network camera is connected to the Raspberry Pi or any processing unit. Libraries such as OpenCV are used to initialize the camera device and set its parameters (e.g., resolution, frame rate) to capture images.Pellentesque habitant morbi.

Converting RGB Images to HSV Color Space

- The captured images are usually represented in the RGB (Red, Green, Blue) color space. This step converts the RGB color space images into the HSV (Hue, Saturation, Value) color space.
- The HSV color space is more suitable for color-related tasks because it separates color and brightness information, making color detection less affected by changes in lighting conditions.

Thresholding and Morphological Operations

- **Thresholding:**
- By setting specific HSV range values, objects of a particular color (e.g., a ball) are identified, and the image is converted into a binary image (containing only black and white), where white represents the target objects and black represents the background.
- OpenCV library is utilized for thresholding to remove irrelevant colors from the image, leaving only parts that match the color of the ball.

- **Morphological Operations:**
- **Erosion**: Removes the edges of white areas, helping to remove small white noise and also separate two touching objects.
- **Dilation**: Increases the size of white areas to compensate for parts removed in the erosion step, restoring the shape of the object.
- **Technical Details**: Erosion and dilation operations are often used in sequence to purify the image. OpenCV provides erode and dilate functions for these operations.

Precisely Locate the Balloon

- **Drawing Contours:**
- Process: Finds and draws contours in the binary image, where contours can be viewed as continuous points that form the boundary of an object.
- Technical Details: OpenCV's 'findContours' function is used to find contours in the image. This step is crucial for identifying and locating spherical objects.

- **Drawing Circles:**
- Process: Using contour information to find the smallest enclosing circle, approximating the detected ball's position and size.
- Technical Details: The 'minEnclosingCircle' function in OpenCV calculates the smallest circle that encloses a given set of points (contour points), simplifying the task of locating the ball.

Control and Movement

- **Raspberry Pi as Brain:** The Raspberry Pi serves as the central processing unit, handling image data analysis and making decisions based on predefined algorithms. It sends commands to the motors based on the processed information.
- **Four-Wheel Drive System:** The SunFounder PiCar-4WD's four-wheel drive system allows for precise control over speed and direction. This ensures the car can swiftly adjust its path to follow the ball, enhancing its ability to maneuver around obstacles and across various surfaces.
- **Motor Control:** The vehicle uses DC motors for movement, with speed and direction controlled by the Raspberry Pi. The integration of motor driver modules enables the Raspberry Pi to manage the motors efficiently, allowing for smooth acceleration and turning.
- **Servo-Controlled Steering:** The PiCar-4WD includes servo motors for steering control, offering the ability to make sharp or subtle changes in direction. This is crucial for accurately tracking and following the ball during experiments.
- **Real-Time Tracking:** Combining the Raspberry Pi's processing power with the PiCar-4WD's responsive movement capabilities allows for real-time tracking of objects. The system can dynamically adjust its actions based on the position and movement of the ball, ensuring continuous engagement.
- **Software-Hardware Integration:** The success of the PiCar-4WD in following and interacting with the ball lies in the seamless integration of software algorithms with the vehicle's hardware components. This synergy between the Raspberry Pi's decision-making and the car's physical movements enables effective real-time response to visual cues.

What are the challenges.

Sensor limitations:

Since the robot uses only camera sensors, there may be limitations on the accuracy of balloon color recognition and distance estimation. Detection of the same color in different lighting situations needs to be considered. The effect of shadows also needs to be considered; the same color, but with different shadows, may be difficult for the algorithm to determine if it is the target color.

Real-time processing:

the robot needs to process the visual data in real time to detect and track the balloon of the specified color. Moreover, the Raspberry Pi platform has limited arithmetic power, so the algorithm must be efficient enough to react quickly in a real-world environment.

What are the challenges.

Obstacle avoidance:

In environments with obstacles, the robot must be able to effectively detect and avoid obstacles to prevent collisions. This requires path planning and environment awareness capabilities.

Hardware and Software Integration:

Effective integration of the camera sensors, Raspberry Pi and PiCar-4WD hardware platforms with the detection and tracking algorithms is key to achieving the project goals.

System stability:

Ensure the stability and reliability of the system throughout the demonstration, especially when running continuously and handling multiple tasks. After completing one balloon tracking task, the next task also needs to be executed reliably.

Testing and Evaluation

Object Capture Distance Test:

Determines the system's maximum detectable distance for balls, verifying the system's effectiveness at various distances.

Color Recognition Capability Test:

Tests the system's ability to recognize balls of different colors by changing the ball's color.

Light Intensity Impact Test:

Evaluates the system's performance under various lighting conditions, ensuring stable operation in diverse environments.

Speed Test:

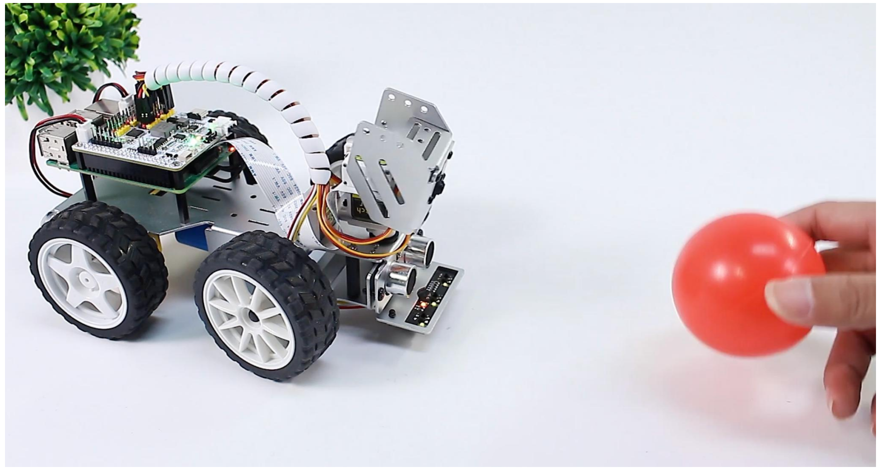
Measures the speed at which the robot tracks and approaches the ball, demonstrating the system's response speed and execution efficiency.

What can be delivered

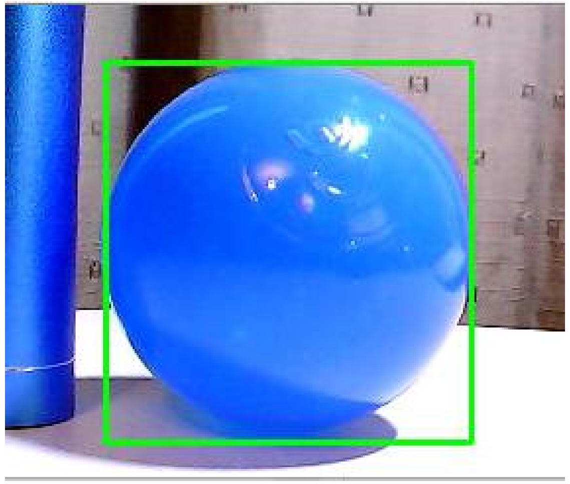
Balloon Detection Robot

We are designing a robot, using the SunFounder PiCar-4WD Car Kit for Raspberry Pi, that can find and approach a balloon of a specific color through webcam footage. This robot can perform the following functions:

- Inspects the environment by adjusting its position and camera.
- Identifies the target balloon.
  - Ignore interference from objects with similar shapes and colors.
  - Enhance image capture to minimize the impact of lighting conditions.
- Plans the path.
  - Moves towards the balloon.
  - Avoids obstacles.



Picture from: [sunfounder.com]



Picture from: [buletin.io]

Division of Labor

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Image processing with OpenCV

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Image processing with OpenCV

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Control and Movement

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Control and Movement

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Testing and Evaluation

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Thanks

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