Team BitFlip
Rescue Line
„If you kinda sort a try, you kinda sort a fail"
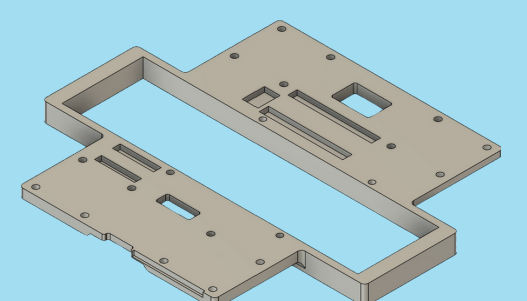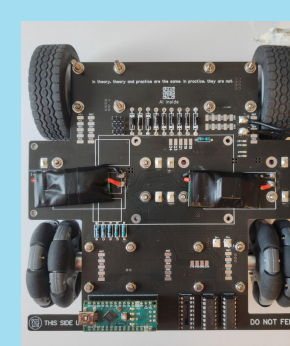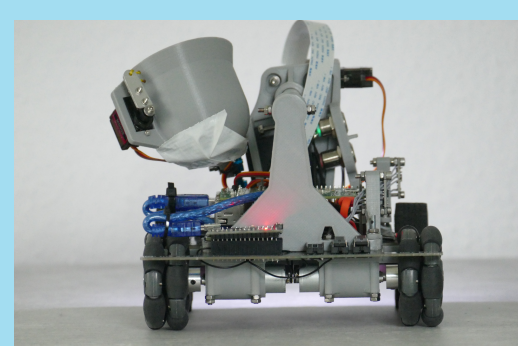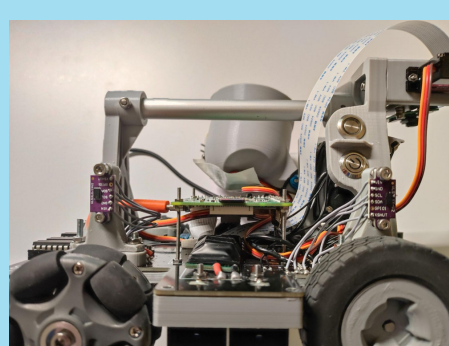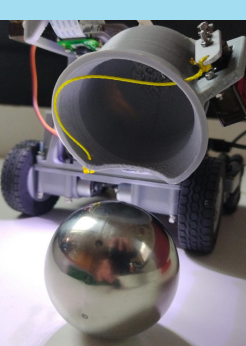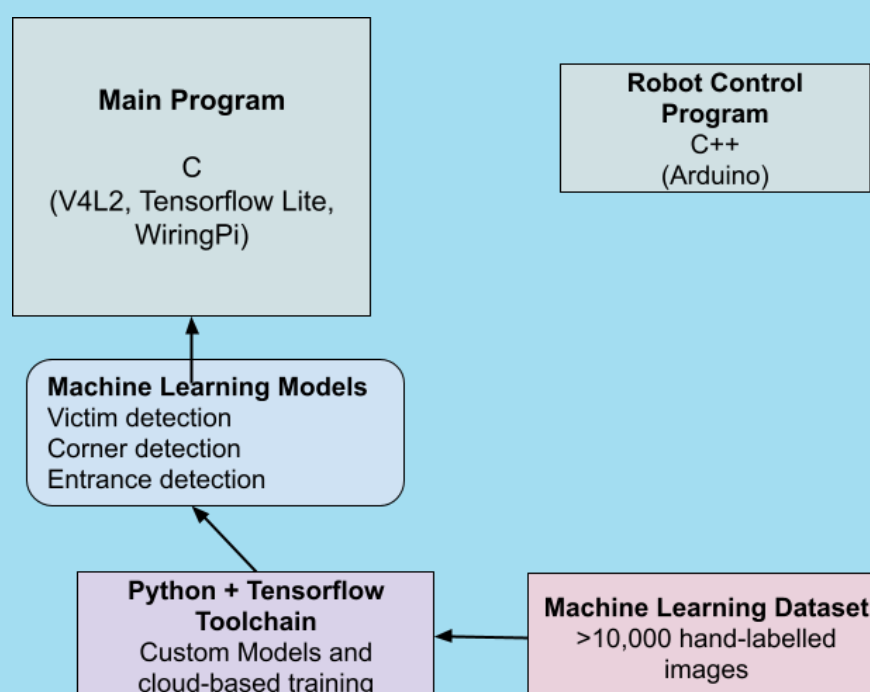
01. Introduction-Team

We are Team BitFlip from Germany and we have been participating in local and international RoboCup competitions for multiple years now. We have all finished school and live all over the country. However, as we have been a team since 2021 and have collaborated for years, working on the robot continues to go smoothly. This requires good project management and a lot of consultation, which happened via frequent video calls. Our team consists of:

- Lukas Kraemer:
  - 19 years old
  - RoboCup since 2017
  - does most of the electrical and mechanical part
  - responsible for YT-Channel and our Website

- Sven Saeger:
  - 19 years old
  - RoboCup since 2016
  - does everything that has to do with software from NN to computer vision

- Jan-Niklas Freund:
  - 18 years old
  - RoboCup since 2017
  - does everything that has to do with planning and organisation
  - maintains the instragram account

02. Achievements

- 2020 qualified for the german championship for the first time
- 2021 Online world championship (top 6)
- 2022 3rd at german championship
- 2022 2nd at european championship Portugal
- 2023 1st at german championship
- 2023 6th at world championship France
- 2024 1st at national qualification
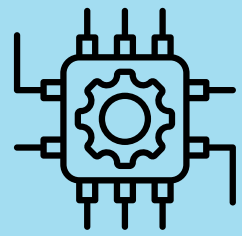
03. Hardware

1.Mechanical Design

- PCB is used as chassis, supported by 3D-printed frame
- powered by four 12V DC Motor (rotation around the front due to use of omni-wheels)
- Arm with a cup for victims --> improvement to last year (more robust, can pickup near walls)
- Distance Sensor for obstacles, Rescue and following walls (two on the side)
- Camera which is tilted up and down by a small servo for following the line and to find victims
- Gyrosensor for precise turning
- No victim container to simplify repairs (easier access to PCB)
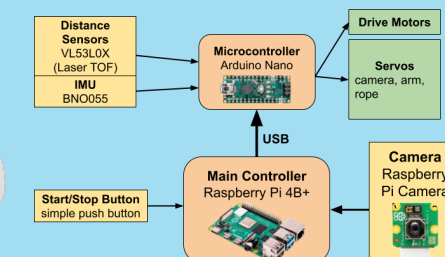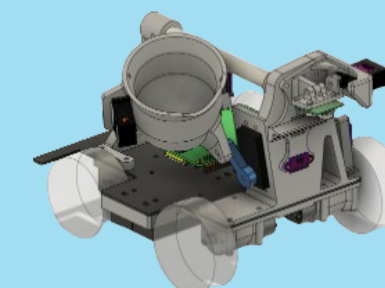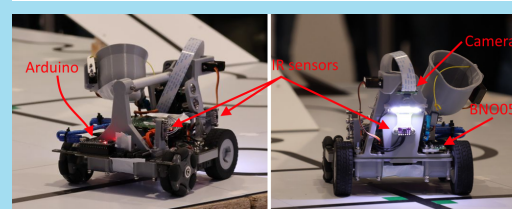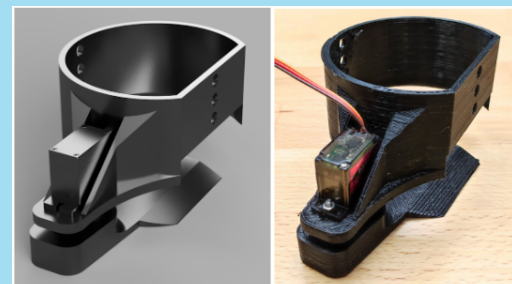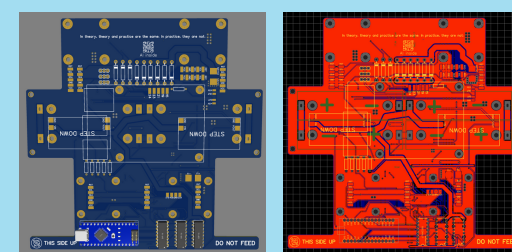
2. Electronic Design

- **Raspberry Pi 4:**
  - runs the main program
  - only start & stop input via button
  - sends motor signals to the Arduino
- **Arduino Nano:**
  - controls all actuators and sensors
- **Power supply**
  - 4x 18650 batteries
  - 2x 5V step-down modules to power Pi and rest separately
  - 12V motors are fed battery voltage (13-16.4V) directly, PWM feedback loop limits max motor voltage to 12V

06. Software

- **General:**
  - main program is in C
  - TensorFlow in our machine learning models
  - Motorcontroller in Arduino C++
  - Python for dataset management and NN training (Google Colab)

Main Program
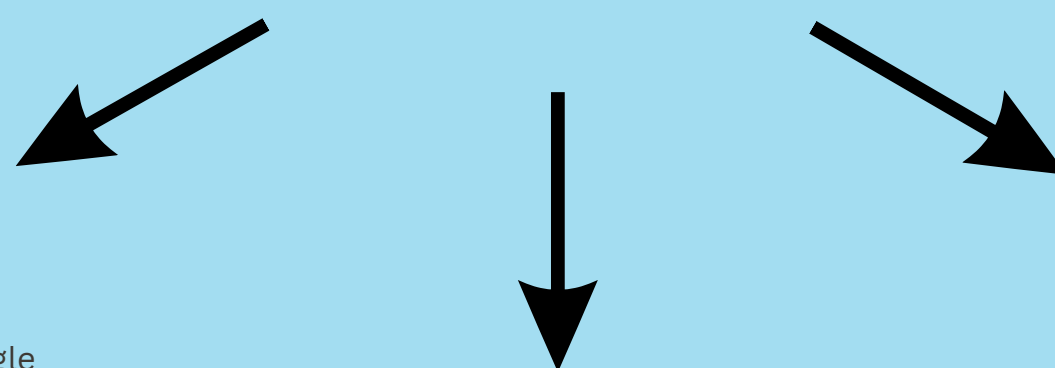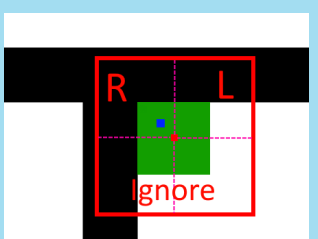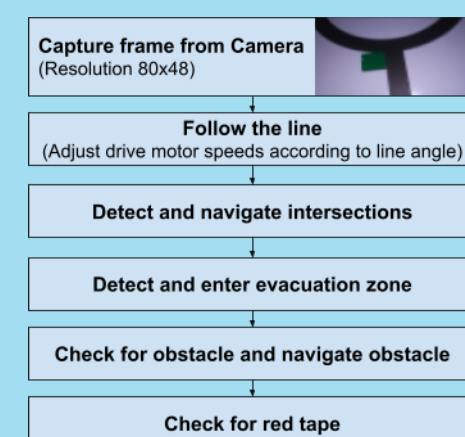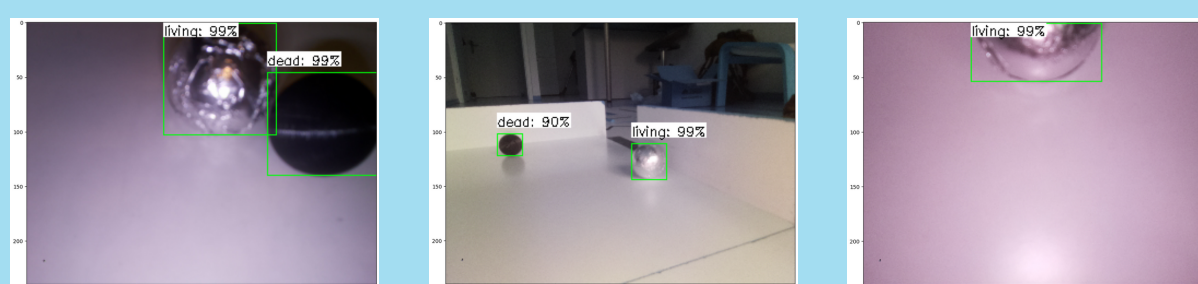C
(V4L2, Tensorflow Lite, WiringPi)

Robot Control Program
C++
(Arduino)

Machine Learning Models
Victim detection
Corner detection
Entrance detection

Python + Tensorflow Toolchain
Custom Models and cloud-based training

Machine Learning Dataset
>10,000 hand-labelled images

- **Victim detection with NN:**
  - Last year we used a self-designed NN architecture (not really reliable)
  - MobileNetV2 suggested by a team at the world championship
    - now we need muss less training data (10k vs 2k images)
    - still better results

- **Simplified linefollowing algorithm:**
  - apply a thresholding operation to separate into black and not black
  - iterating over every pixel
  - each pixel gets an angle
  - pixel which are closer to the bottom are getting more weight
  - use average angle of pixels as error for a PD controller
  - More information in the TDP (can be found on our website/GitHub)

Capture frame from Camera (Resolution 80x48)

Follow the line (Adjust drive motor speeds according to line angle)

Detect and navigate intersections

Detect and enter evacuation zone ↔ **Entrance detection thread**

Check for obstacle and navigate obstacle

Check for red tape

07. Some more pictures