# Software Survey 2025

## Team Name

Boosted HTWK

## Is your software fully or partially OpenSource. If so, where can it be found:

partially, https://github.com/BoosterRobotics, https://github.com/NaoHTWK

## Do you have a kinematic or dynamic model of your robot(s)? If so, how did you create it (e.g. measure physical robot, export from CAD model)?

Yes. We design our robot CAD model using Solidworks and it can be easily converted into Unified Robotics Description Format by the OpenSource ROS sw_urdf_exporter. Once the URDF has been created, the dynamic properties can be loaded in simulation and algorithm.

## Are you using Inverse Kinematics? If so what solution (analytic, (pseudo)inverse jabcobian, etc...) are you using?

Yes, we use inverse kinematics. We compute the inverse kinematics iteratively using a damped Levenberg-Marquardt method (also known as Damped Least Squares method).

## Are you simulating your robot? If so what are you using simulation for?

Yes

- reinforcement learning of locomotion
- developing and validating team strategy behavior
- validating end-to-end software

## What approach are you using to generate the robot walking motion?

We are using reinforcement-learning for locomotion and push recovery.

## What approach are you using to generate motions for standing up?

Reinforcement learning.

## What approach are you using to generate kicking motions?

Reinforcement learning.

## Do you use any other motions than the previously mentioned? If so, what approaches are you using to generate them?

All custom motions are generated through reinforcement learning.

## Which datasets are you using in your research? If you are using your own datasets, are they public?

Data recorded during previous games in Humanoid and Standard Platform leagues. Data is not public.

## What approaches are you using in your robot's visual perception?

Convolutional neural networks, classical image segmentation (e.g. scanlines)

Our approach for SPL 2023 can be found here: https://github.com/NaoHTWK/HTWKVision

A similar approach using the added computational capability will be used for the upcoming competition.

## Are you planning with objects in Cartesian or image space? If you are using Cartesian space, how do you transform between the image space and cartesian space?

Cartesian. Fusion of forward kinematics, IMU values, and odometry.

## How is your robot localizing?

A set of potential locations is continuously determined through detected field lines and other field markers (e.g. goal posts and penalty spots). It is then filtered and combined for temporal plausibility, achieving better performance than particle filters at a fraction of the computational cost.

## Is your robot planning a path for navigation? Is it avoiding obstacles? How is the plan executed by the robot (e.g. dynamic window approach)?

We employ multiple levels of obstacle avoidance.

Long distance obstacles: A CNN trained to detect robots is used to determine the position of robots across the field. This data is used by the team strategy module to prefer playing into “empty” parts of the field, thus avoiding opponent contact.
Short distance obstacles: A separate low resolution CNN is detecting “obstacles” (including fallen robots and referees). Obstacles are then either avoided by moving sideways towards unoccupied space; or, e.g. if a ball is between us and a fallen opponent, our robot will wait for the fallen robot to get up or be removed before proceeding.
Earlier versions of both obstacle detectors can be found here: https://github.com/NaoHTWK/HTWKVision

## How is the behavior of your robot's structured (e.g. Behavior Trees)? What additional approaches are you using?

Agent based. The team strategy defines a set of dynamically assigned roles that each behave in a dynamic fashion depending on the location of our own robots, the opponent robots, the ball, and the state of the game. Execution of the assigned high-level role is then handed off to a set of lower level behaviors like dribbling or kicking.
An earlier implementation of the team behavior can be found here: https://github.com/NaoHTWK/HTWKStrategy

## Do you have some form of active vision (i.e. moving the robots camera based on information known about the world)?

We are continuously tracking the ball and have specific efficient head motions for tasks like ball search or to improve localization accuracy.

## Do you apply some form of filtering on the detected objects (e. g. Kalman filter for ball position)?

We use Kalman filters for tracking the ball and opponent robots.

## Is your team performing team communication? Are you using the standard RoboCup Humanoid League protocol? If not, why (e.g. it is missing something you need)?

We currently use the standard SPL message and will adjust to the Humanoid Kid Size specifications. Our team behavior is optimized for efficient communication between robots.

## Please list contributions your team has made to RoboCup

We have taken part in every SPL competition since 2009, SPL world champion at Robocup Montreal 2018. A lot of our code has been released as open source and has been used by other teams. We have also been active in the SPL league as OC, TC, and Exec members.

## Please list the scientific publications your team has made since the last application to RoboCup (or if not applicable in the last 2 years).

Bachelor thesis, 2024 - “Training und Evaluation eines neuronalen Netzes zur Lösung der „Visual Referee Challenge“”, Freijdis Jurkat

Bachelor thesis, 2024 - “Sturzvorhersage bei humanoiden Robotern mithilfe von Machine Learning”, Max Liebing

Bachelor thesis, 2024 - “Bildverarbeitungsmethoden zur zuverlässigen Mustererkennung auf dem Roboterjersey im humanoiden Roboterfußball”, Lea Kunz

Bachelor thesis, 2024 - “Testing Game Theoretic Dimensions of Team Strategies via Simulation for Robotic Soccer in the RoboCup Standard Platform League”, Leah Herrfurth

Bachelor thesis, 2024 - “Stabilisierung von humanoiden Robotern mithilfe dynamischer Korrekturen durch Vorwärtskinematik”, Eric Behrendt

## Please list the approaches, hardware designs, or code your team is using which were developed by other teams.

none

## What operating system is running on your robot and which middleware are you using (for example Ubuntu 22.04 and ROS2 Galactic)?

Ubuntu 22.04. Some parts of the code use ROS2 while others use self-developed middleware frameworks.

## Is there anything else you would like to share that did not fit to the previous questions?

Boosted HTWK is a collaboration between Booster Robotics (hardware+locomotion) and HTWK Robots (behavior+image processing)

**If you have additional materials you would like to show, please link to them here.**