Soccer robots by software engineers

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for
RIF Team

Robocup MSL International Workshop
Eindhoven, 22-24 November 2019
RIF Robocup team
RIF Robocup team
RIF team

• Applied research on autonomous mobile robotics
• Students and lecturers/researchers working together
• Student team
• Open challenge-based learning
• Software Engineering principles
RIF robot

- Electric Skateboard technology

ESP32 Microcontroller

Electronic Speed Controllers

Brushless DC motors
RIF robot

Camera –
5MP 160 Fish eye

PC -
Jetson TX2
Robot architecture

Robot uses underlying positioning system. Called TF positioning. Every node can publish or subscribe to TF if needed.

Communicates with other robots by synchronizing the RTDB CAMBADA database.

ROS
Open Source Robotics Foundation
Robot architecture

Worldmodel

“Think before you act”

Perception

Sensors

“Think the way you act”

Actions

Actuators
AI for Robotics

• Perception AI
  – Detect objects such as ball, obstacles, humans
  – Localisation using camera images of the soccer field
  – Human pose estimation & recognition of intentions

• Action AI
  – Navigation
  – Action selection
AI is non-deterministic

- Sensors are noisy
- Perception is uncertain
- Best possible is predict, estimate
  - Build belief – probability
- Learning with AI
  - Minimize loss (errors)
  - Maximize reward (utility)
Perception AI

Perception

Sensors

Worldmodel

“Think before you act”

Actions

“Think the way you act”

Actuators
Perception AI

- OpenPose (CMU) - 17 keypoints
Perception AI

AGV with interaction module
Localisation

- Convolutional Neural Network + Sensor Fusion

- odometry (wheel encoders)
- orientation (imu)
- image (camera)

"Kalman filter"
Action AI

Worldmodel

“Think before you act”

Perception

Actions

“Think the way you act”

Sensors

Actuators

“Think the way you act”
Action Selection

- Model based

Skills
Move
Intercept
Dribble,
Pass,
Shoot...

STATE
WorldModel

ACTION

POLICY
Robot skills

Legend:
- Package
- Library
- Implemented node
- Node in progress
- Unimplemented node
- Implemented behavior
- Behavior in progress
- Unimplemented behavior

Action planning

- Passing
- Shooting
- Moving
- Interpose
- Dribbling
- ...

- Kick behavior
- Aim behavior
- MoveTo behavior
- ...
- ...
Navigation

- Artificial Potential Field

Attraction + Repulsion
State machine

WithoutBall

Position

Intercept

[-ballFree]

[bballFree]

[ballFree]

[-ballFree]

WithBall

[-hasBall]

[hasBall]

[-canShoot ^ canPass]

[canShoot]

[canShoot]

[~canShoot ^ canPass]

[~canShoot ^ canPass]

Dribble

Pass

Shoot
Behavior tree

- \( \emptyset \)
- \( ? \)
- \( ? \)
- \( ? \)
- \( ? \)
- hasBall
- ballFree
- Intercept
- canShoot
- Shoot
- canPass
- Pass
- Dribble
- Position
Action selection models

- Hierarchical State Machine
  - Verifiable
- Behavior Tree
  - Maintainable
- Neural Network
  - Trainable

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(Andova, Dortmans, Punter, 2019)
Next steps

- Ball detection and basic skills
- Localisation and navigation
- Engineering own robot behavior
- Reverse engineering opponent robot behavior

Degree of difficulty
Continuous Integration

- GitLab repository
- CI/CD Pipeline
Simulator

2D – Stage
3D - Gazebo
Thank you

• Questions or remarks?