Falcons team presentation

MSL workshop Eindhoven, 22-24 nov 2019

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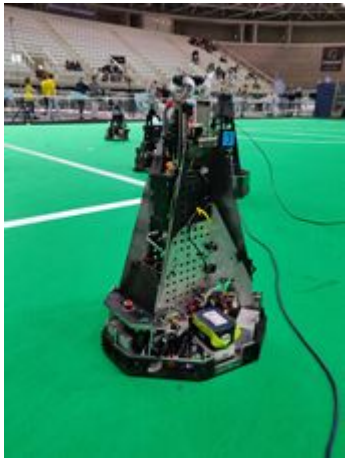
Contents

- General
- New hardware platform
- Software: usability & diagnostics
- “MultiCam” as OmniVision system
  - Machine Learning in Falcons software

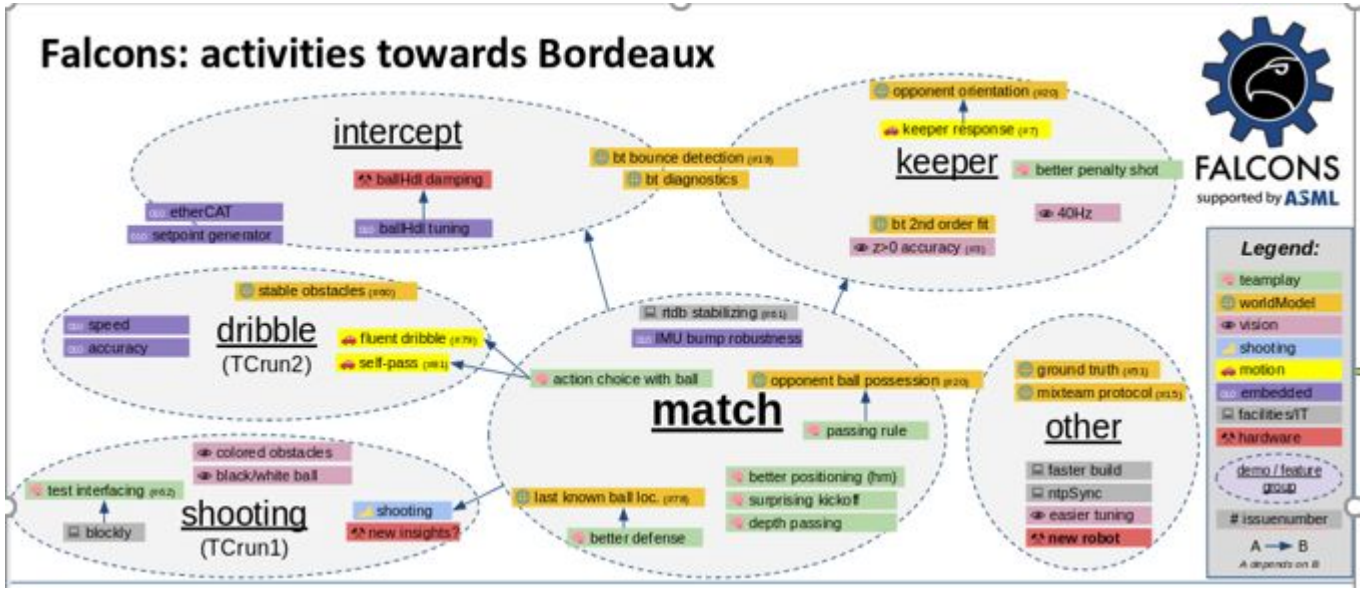
General

2018-2019:

- Introduction of new Proto Robot 7
- Introduction Extendable Keeper Frame
- 3rd place Robotica Portugal 2019
- 3rd Place Robocup 2019 Sydney
- Robot uptime very high
- Increase in manpower from 17 to 46 right now
- Creation of New Organization Structure



Road to Bordeaux



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New hardware platform

New hardware platform

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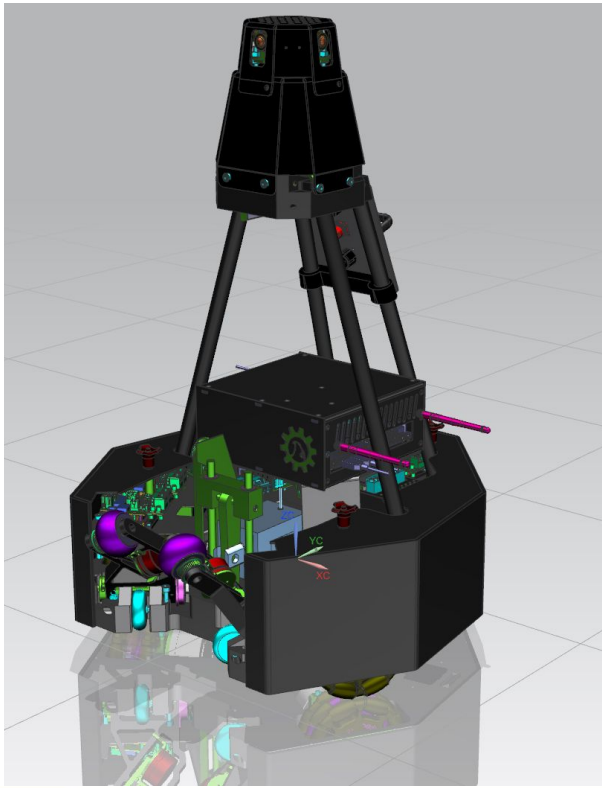
- reasons for redesign:
  - enable faster motion
  - improved serviceability (modularity)
  - stiffer bottom frame
  - . . .

- targeting 1 working robot Portugal 2020



New hardware platform

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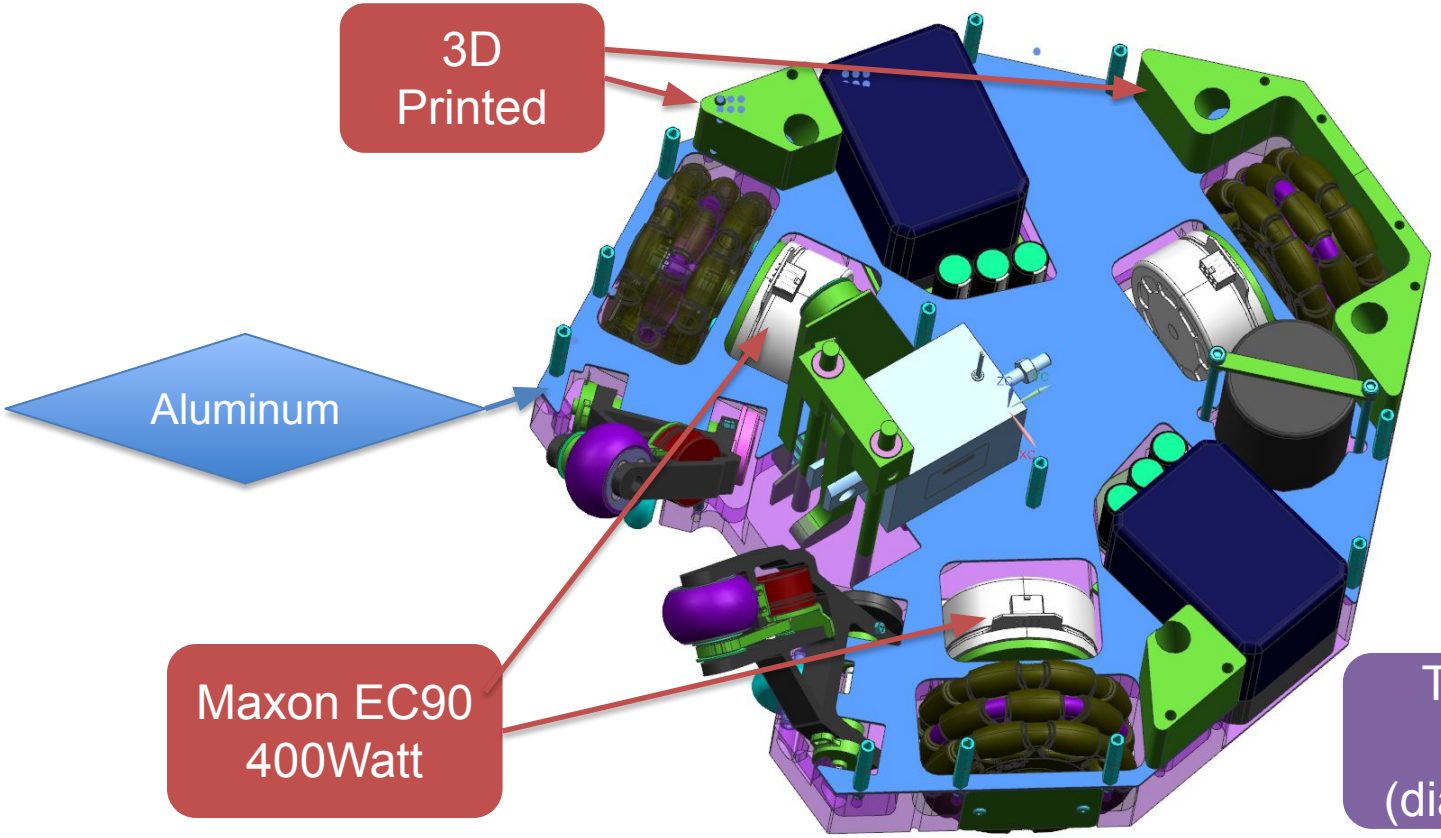

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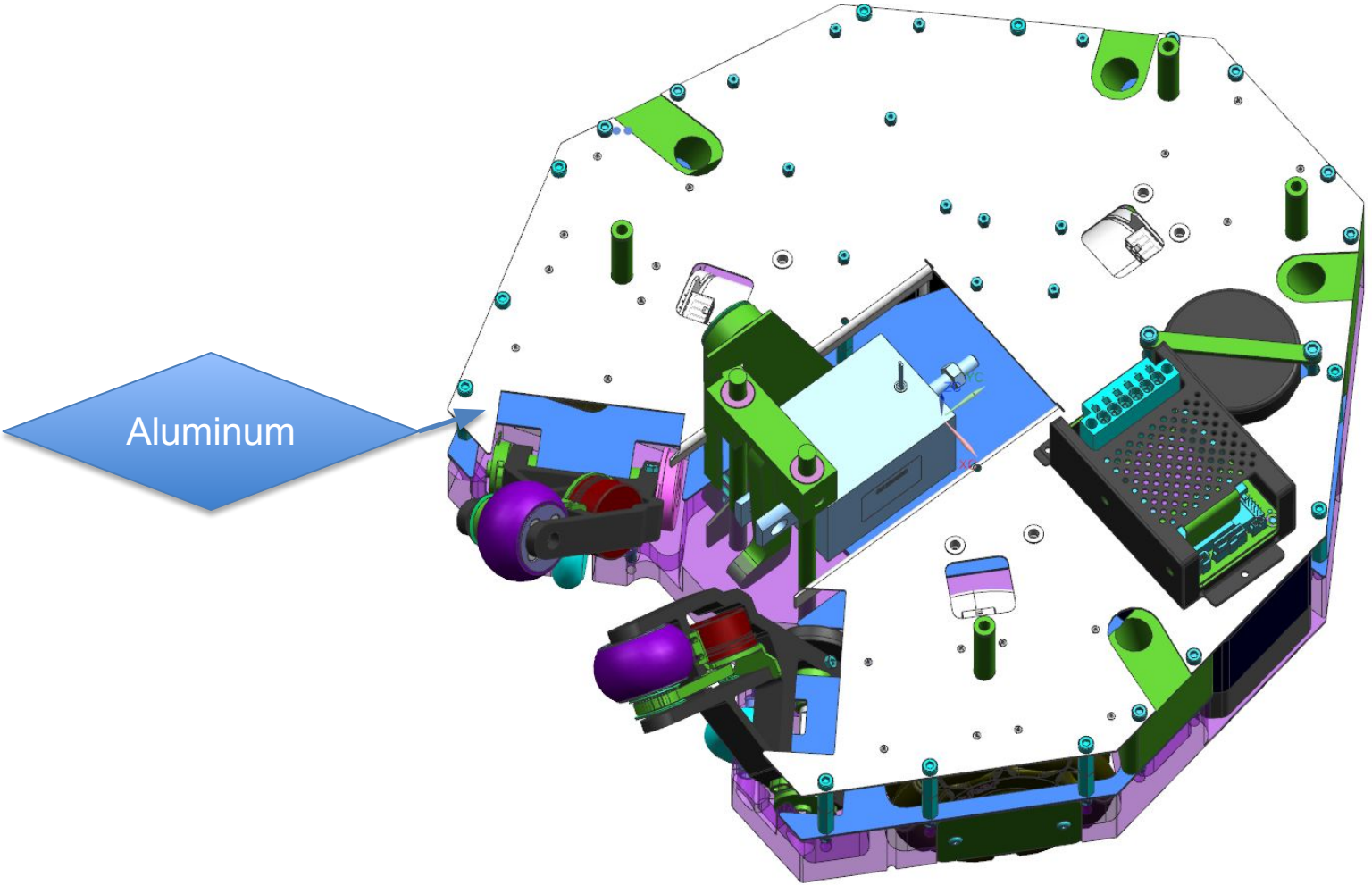

New hardware platform

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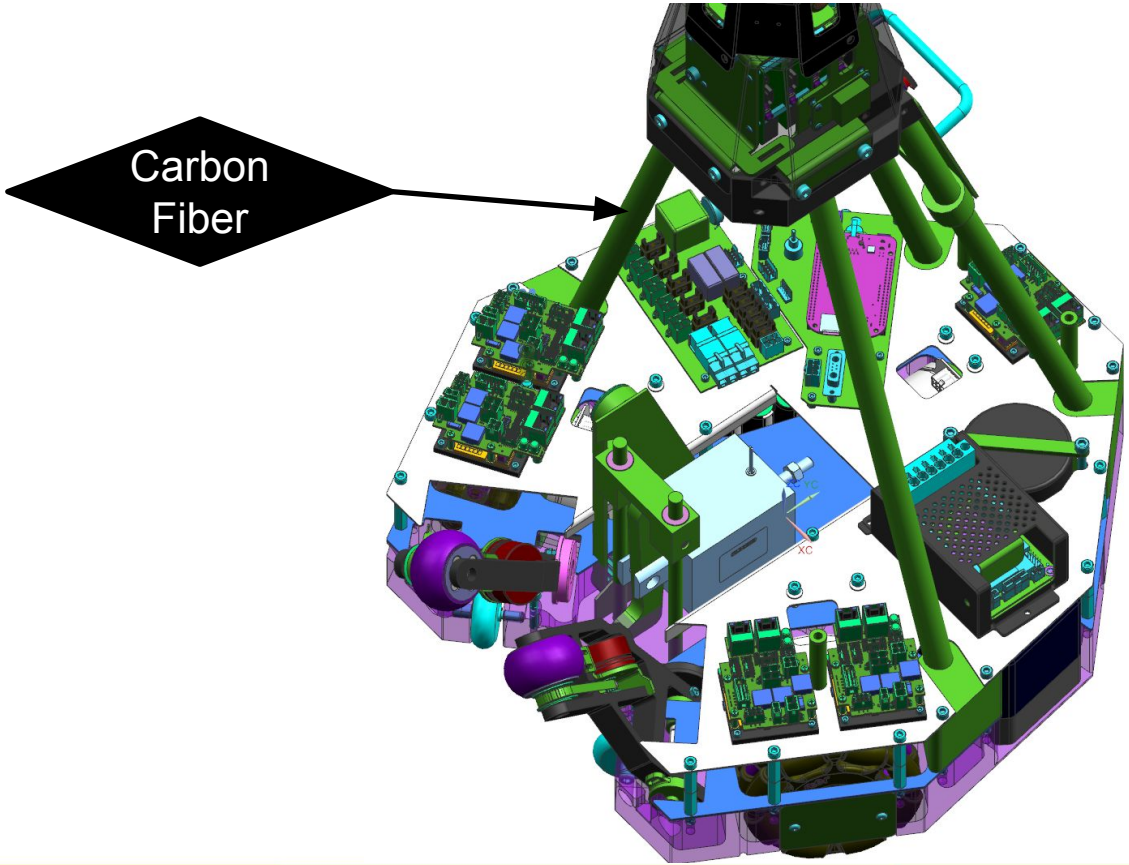

Ballhandlers concept

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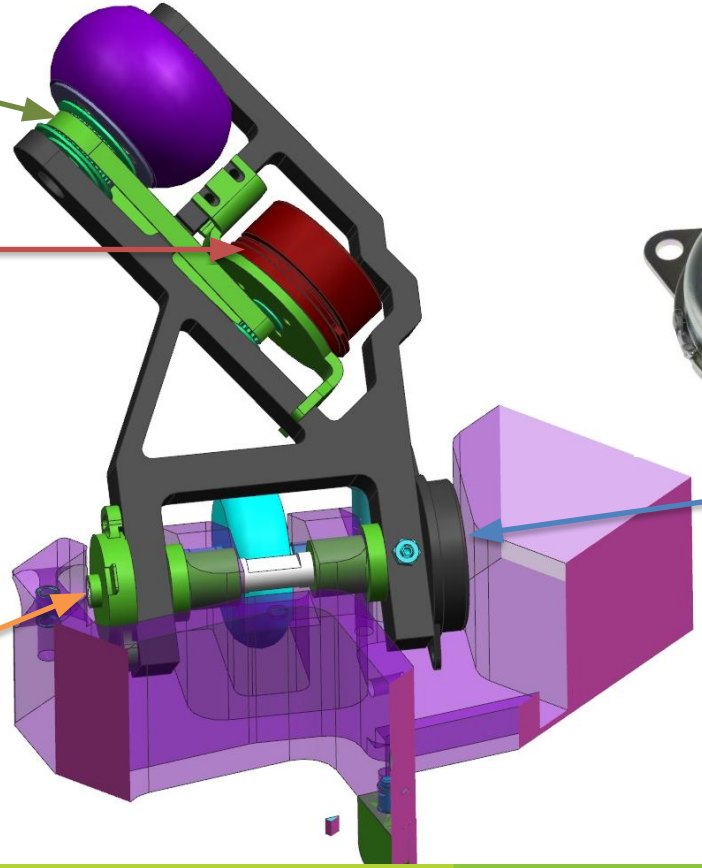
Belt Driven

High Torque EC45

Rotary Damper

Linear Angle Sensor



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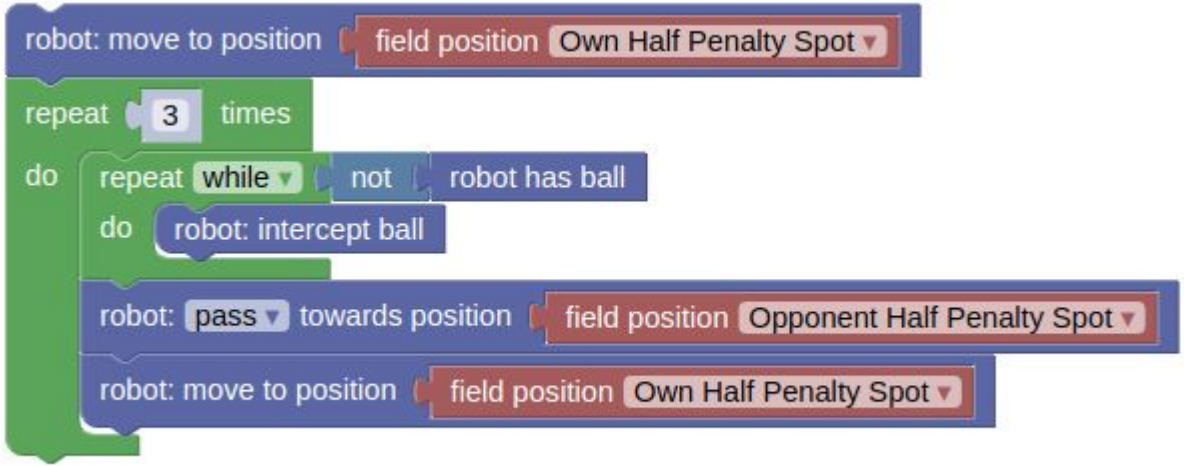
Software: usability and diagnostics

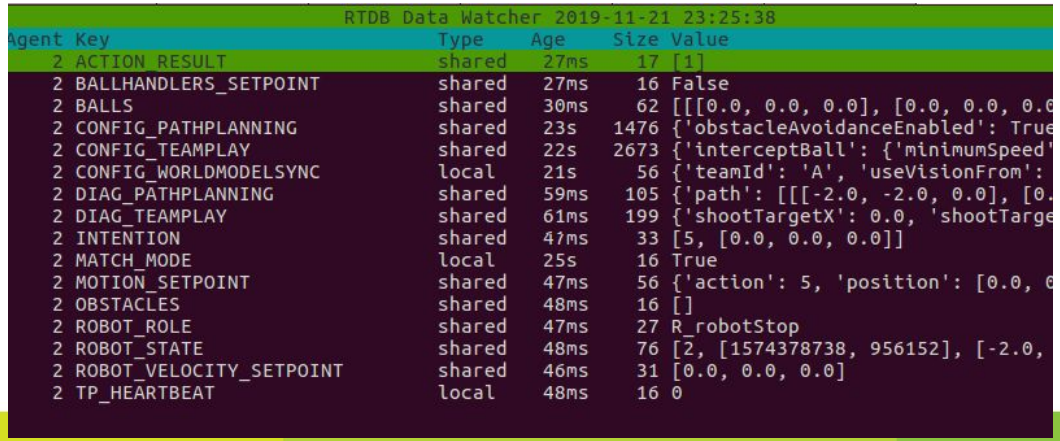
Usability

- Testing the robot made easy: Google Blockly
- Inspired by VDL RobotSports



Diagnostics

- The robot is not behaving as expected ⇒ How do you pinpoint the root cause?
- Step 1: Find the software component this is showing unexpected behavior
  - Playback what the robot was thinking
    - playback takes a **`.rdl`** file: RTDB Data Logging
      - can be from baseStation (shared data) or robot (more/local data)
      - is a sequence of zipped RTDB frames, similar to what **`comm2`** is using
    - during playback, one can inspect RTDB contents, or connect other diagnostics tools



RTDB Data Watcher 2019-11-21 23:25:38

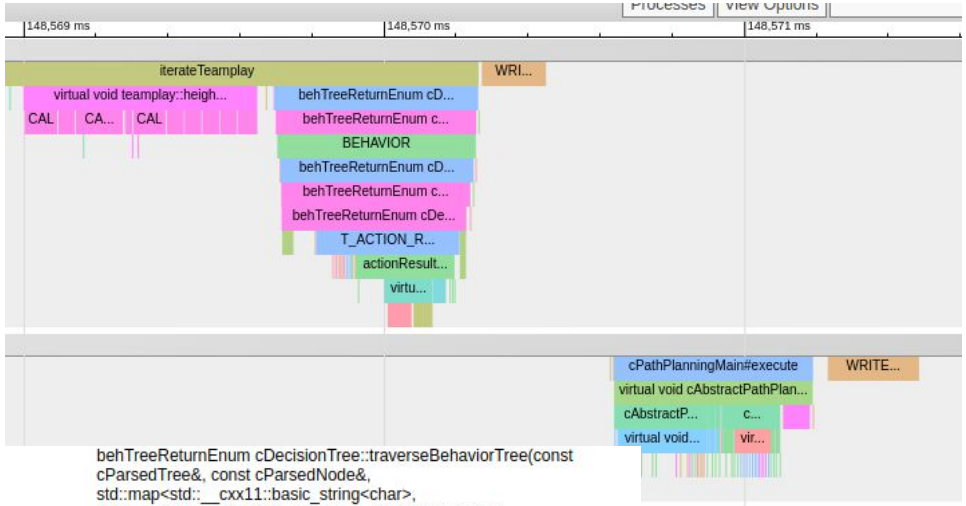
Agent	Key	Type	Age	Size	Value
2	ACTION_RESULT	shared	27ms	17	[1]
2	BALLHANDLERS_SETPOINT	shared	27ms	16	False
2	BALLS	shared	30ms	62	[[[0.0, 0.0, 0.0], [0.0, 0.0, 0.0
2	CONFIG_PATHPLANNING	shared	23s	1476	{'obstacleAvoidanceEnabled': True
2	CONFIG_TEAMPLAY	shared	22s	2673	{'interceptBall': {'minimumSpeed'
2	CONFIG_WORLDMODELSYNC	local	21s	56	{'teamId': 'A', 'useVisionFrom':
2	DIAG_PATHPLANNING	shared	59ms	105	{'path': [[[-2.0, -2.0, 0.0], [0.
2	DIAG_TEAMPLAY	shared	61ms	199	{'shootTargetX': 0.0, 'shootTarge
2	INTENTION	shared	47ms	33	[5, [0.0, 0.0, 0.0]]
2	MATCH_MODE	local	25s	16	True
2	MOTION_SETPOINT	shared	47ms	56	{'action': 5, 'position': [0.0, 0
2	OBSTACLES	shared	48ms	16	[]
2	ROBOT_ROLE	shared	47ms	27	R_robotStop
2	ROBOT_STATE	shared	48ms	76	[2, [1574378738, 956152], [-2.0,
2	ROBOT_VELOCITY_SETPOINT	shared	46ms	31	[0.0, 0.0, 0.0]
2	TP_HEARTBEAT	local	48ms	16	0

Playback merged with video

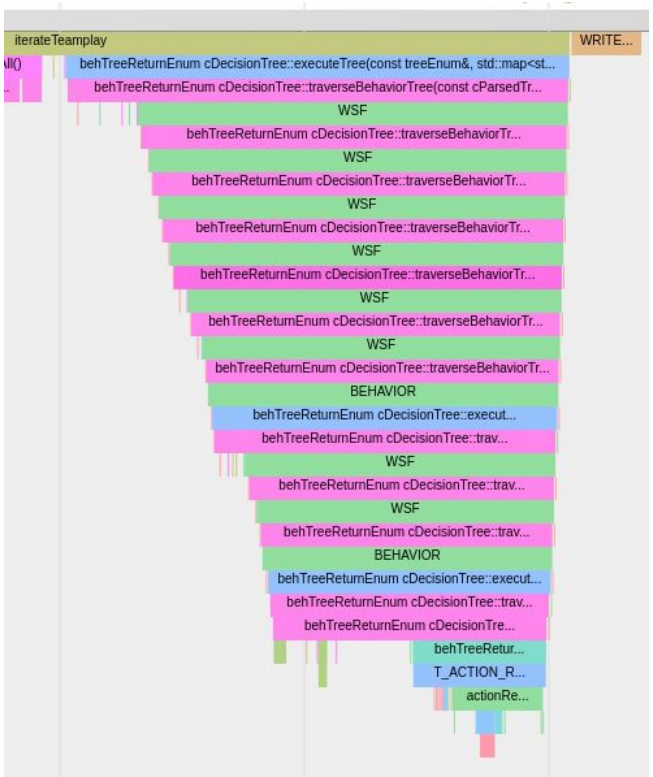
- camera on top of field as *“ground truth”*
- processing after match:
  - one-time action
  - dewarp, field border lines
  - time sync video w.r.t. RDL

Diagnostics

- Step 2: Zoom in on software component
  - Chromium Tracing Framework



Title	behTreeReturnEnum cDecisionTree::traverseBehaviorTree(const cParsedTree&, const cParsedNode&, std::map<std::__cxx11::basic_string<char>, std::__cxx11::basic_string<char> >&, const treeEnum&, memoryStackType&, int, memoryStackNodes&)
Category	/home/robocup/falcons/code/packages/teamplay/src/cDecisionTree.cpp
User Friendly Category	other
Start	20,896.468 ms
Wall Duration	1.588 ms
Self Time	0.057 ms
Args	
msg	"tree: defenderMain; node: wsf:doesOwnRobotHaveBall"



Diagnostics

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- BaseStation stores:
  - `.rdl` file containing shared RtDB data for all robots, allowing playback.

- Every robot stores:
  - `.rdl` file containing detailed local RtDB data for the robot itself, and shared RtDB data from other robots, allowing playback from detailed robot perspective.
  - Trace files for all software components, containing every single decision made during the match.

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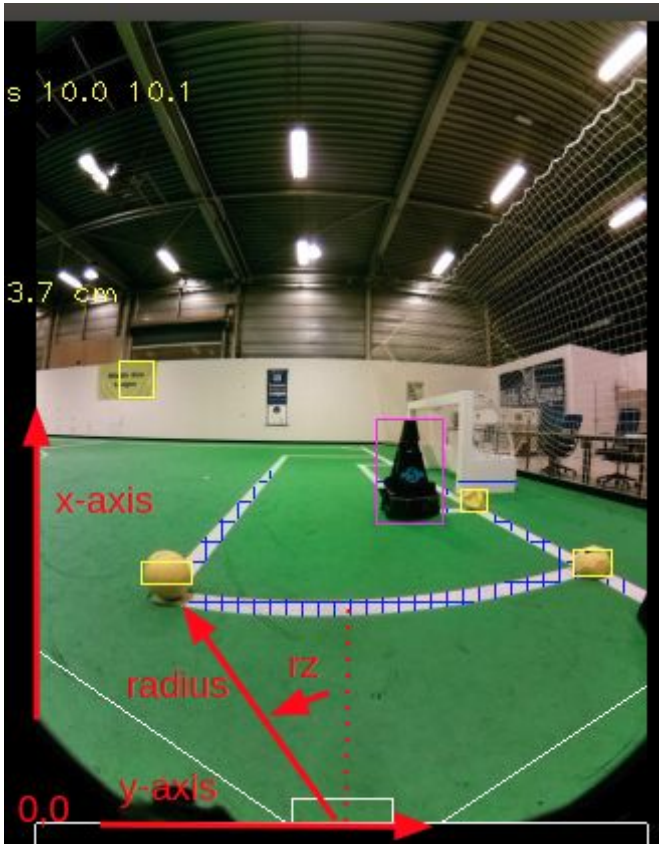
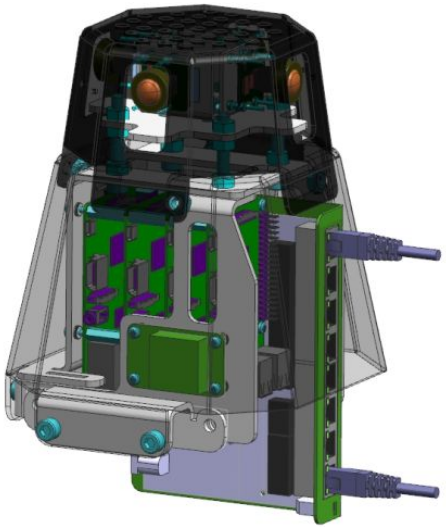
“MultiCam” as OmniVision system

MultiCam front view



showing 1 out of 4 cameras
~100° horizontal (600px)
~135° vertical (800px)
large fisheye distortion



Localization using MultiCam

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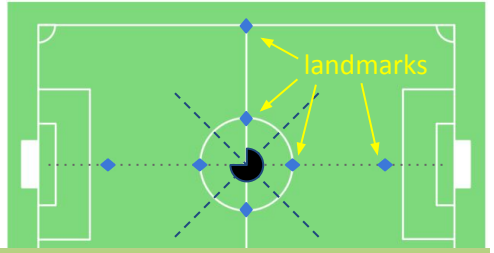
- calibration:
  - fisheye per camera (intrinsic parameters)
  - mounting/pointing errors using field **landmarks** (extrinsic parameters)
  - quite accurate, **robust** and fast, using opencv3



- per camera, *line point detection* is done
  - using a **lookup table** to transform white pixel coordinates to robot coordinate system

- the result of 4 cameras is used in localization:
  a ***simplex*** algorithm determines position candidates using the selected white pixels in robot coordinates

- filtering & selection of candidates is done by worldModel
  - same architecture principle for localization, balls and obstacles

Machine learning @Falcons

- we see two main candidate applications for Machine Learning in Falcons software:
  - ***teamplay*** (= decision making, choice of robot action)
  - computer ***vision***

- teamplay
  - our SW stack behaves “deterministic”, using decision trees and tuned height maps as function of world state
  - mainly for ease of development and diagnostics purposes
  - this will probably remain the case for coming year(s), so no Machine Learning
- vision
  - current vision system is sensitive to lighting changes
  - furthermore, filter design and tuning is complex / labour-intensive
  - **this year, we are considering Machine Learning** for ball- and obstacle detection
    - regular black&white balls
    - obstacles of arbitrary shape/colors

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End - questions?

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Backup slides

Backup: MultiCam system features

- 4 cameras
  - ~100 degrees horizontal and ~135 degrees vertical
  - MIPI CSI-2 (raw data/low latency interface)
- 4 Raspberry 3B+
  - 4 x A53 CPU (used for pre-processing)
- X86_64
  - Detection, Localization, Synchronization, Control, deWarp,..
  - Ethernet connection between raspi's and x86_64
- Pro
  - Way better view than old omni camera (~6 meters vs 3.5m)
  - "Low" latency (complete vision ~50 ms, possibility to ~40ms)
  - Works pretty good!
- Cons
  - Cross platform, more work to maintain
  - **Same high dependency on color calibration**
  - Obstacles sometimes merged with border
  - Rather complex state machine / rules to handle exceptions