



Winning the RoboCup SPL Competition

Bernhard Hengst

Humanoids 2015 – 10th Workshop on Humanoid Soccer Robots

3rd Nov 2015

Never Stand Still

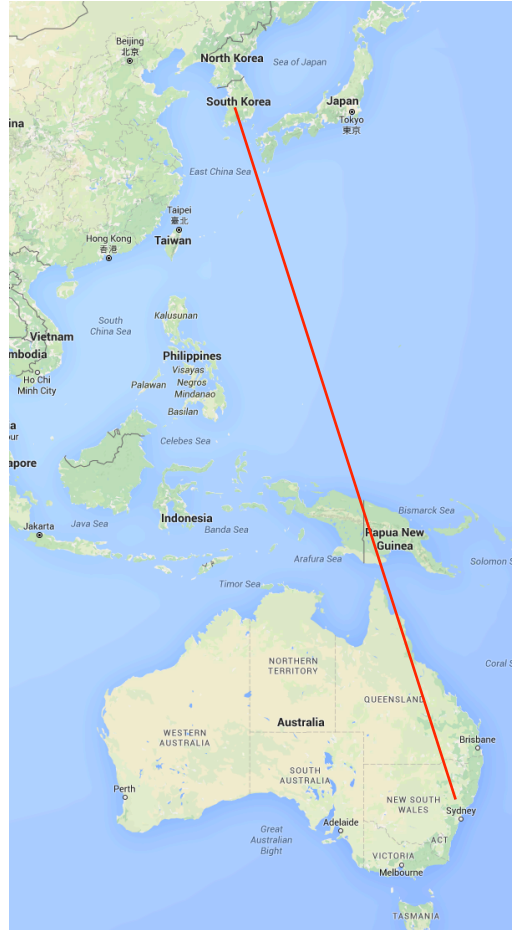
Faculty of Engineering

Computer Science and Engineering

UNSW

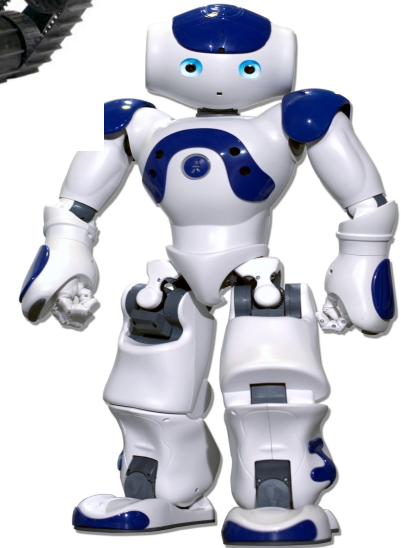
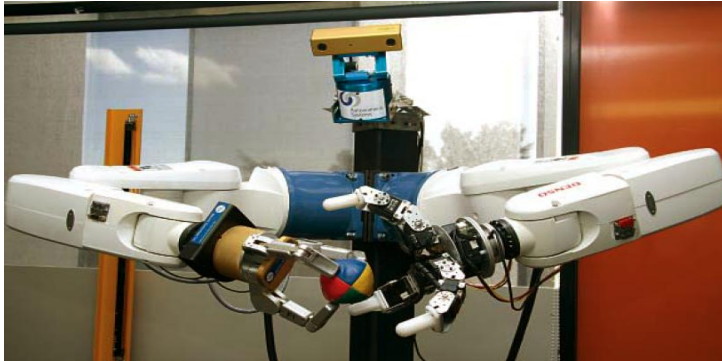
Sydney

50,000 Students from 128 Countries



Robotics at CSE

- A cognitive robot does not simply act and react to the world around it; rather, it thinks about that world and uses what it knows to help it decide what actions to perform
- Combine reasoning (planning) with domain specific knowledge



Team Members since 2010

2010

Jayen Ashar, David Claridge, Brad Hall, Bernhard Hengst, Hung Nguyen, Maurice Pagnucco, Adrian Ratter, Stuart Robinson, Claude Sammut, Benjamin Vance, Brock White, Yanjin Zhu

2011

David Claridge, Brock White, Carl Chatfield, Sean Harris, Belinda Teh, Jimmy Kurniawan, Yongki Yusmanthia, Youssef Hunter, Yiming Deng, Manuel Lange, Hung Nguyen, Jarupat Jisarojito, Benjamin Vance, Jayen Ashar, Brad Hall, Bernhard Hengst, Claude Sammut, Maurice Pagnucco

2012

Peter Anderson, Carl Chatfield, Sean Harris, Richard Hua, Youssef Hunter, Sam Li, Roger Liu, Ritwik Roy, Belinda Teh, Brad Hall, Bernhard Hengst, Maurice Pagnucco, and Claude Sammut

2013

Beth Crane, Richard Hua, Jack Murray, Dan Padiha, Stephen Sheratt, Calvin Tam, Alexander Whillas, Jayen Ashar, Sean Harris, Brad Hall, Bernhard Hengst, Maurice Pagnucco, Claude Sammut

2014

Jayen Ashar, Jaiden Ashmore, Brad Hall, Sean Harris, Bernhard Hengst, Roger Liu, Zijie Mei (Jacky), Maurice Pagnucco, Ritwik Roy, Claude Sammut, Oleg Sushkov, Belinda Teh, Luke Tsekouras

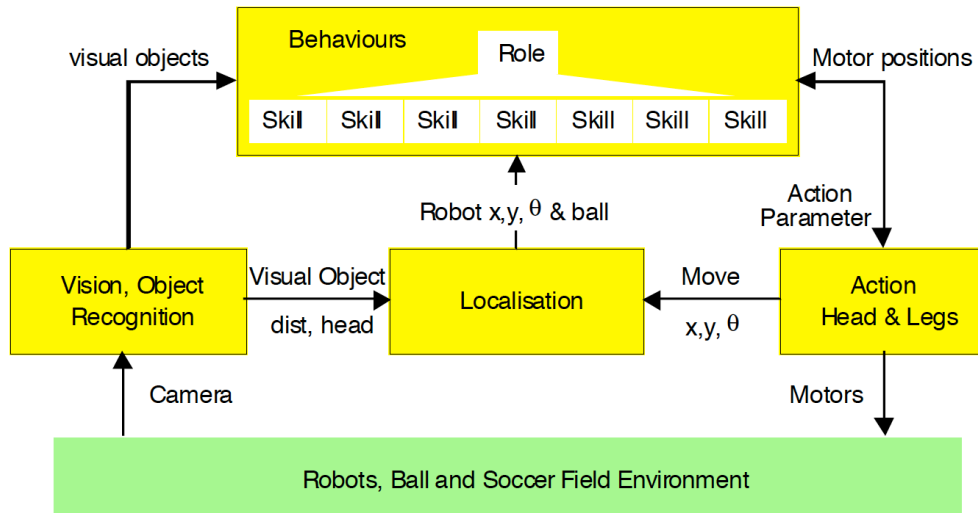
2015

Kenneth Ng, Luke Pearson, Peter Schmidt, Ritwik Roy, Roger Liu, Sean Harris, Jayen Ashar, Brad Hall, Bernhard Hengst, Maurice Pagnucco, and Claude Sammut

Our First Year



RoboCup 2000

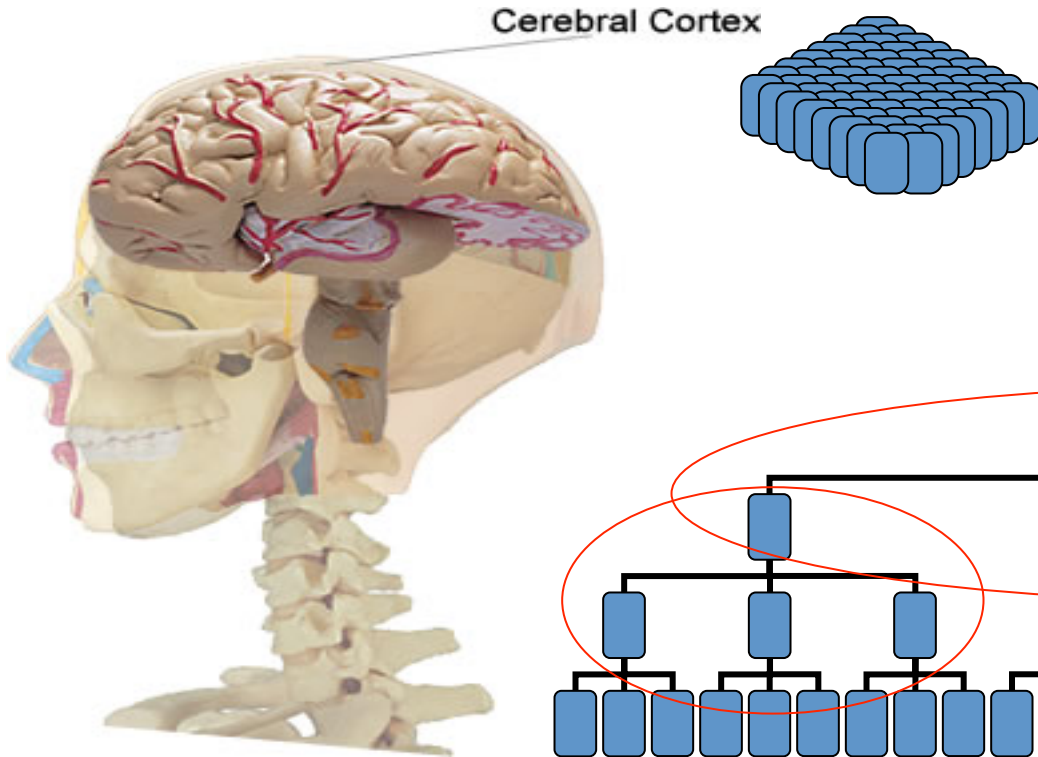


Overview

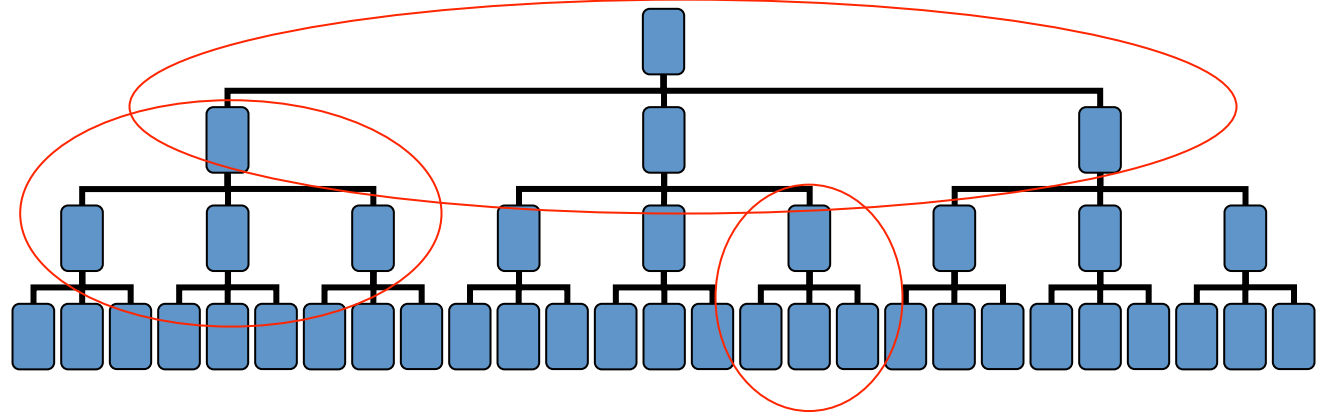
More Recent Developments

- Architecture
- Vision
 - Colour
 - Foveated vision
 - Natural landmarks
 - Field Edge, Corner Features
 - ICP
 - Robot Detection
- Localisation - Shared KF
- Locomotion and kicks
- Skills and strategy
- 2015 Whistle, Foot detection, Goals
- Team Organisation

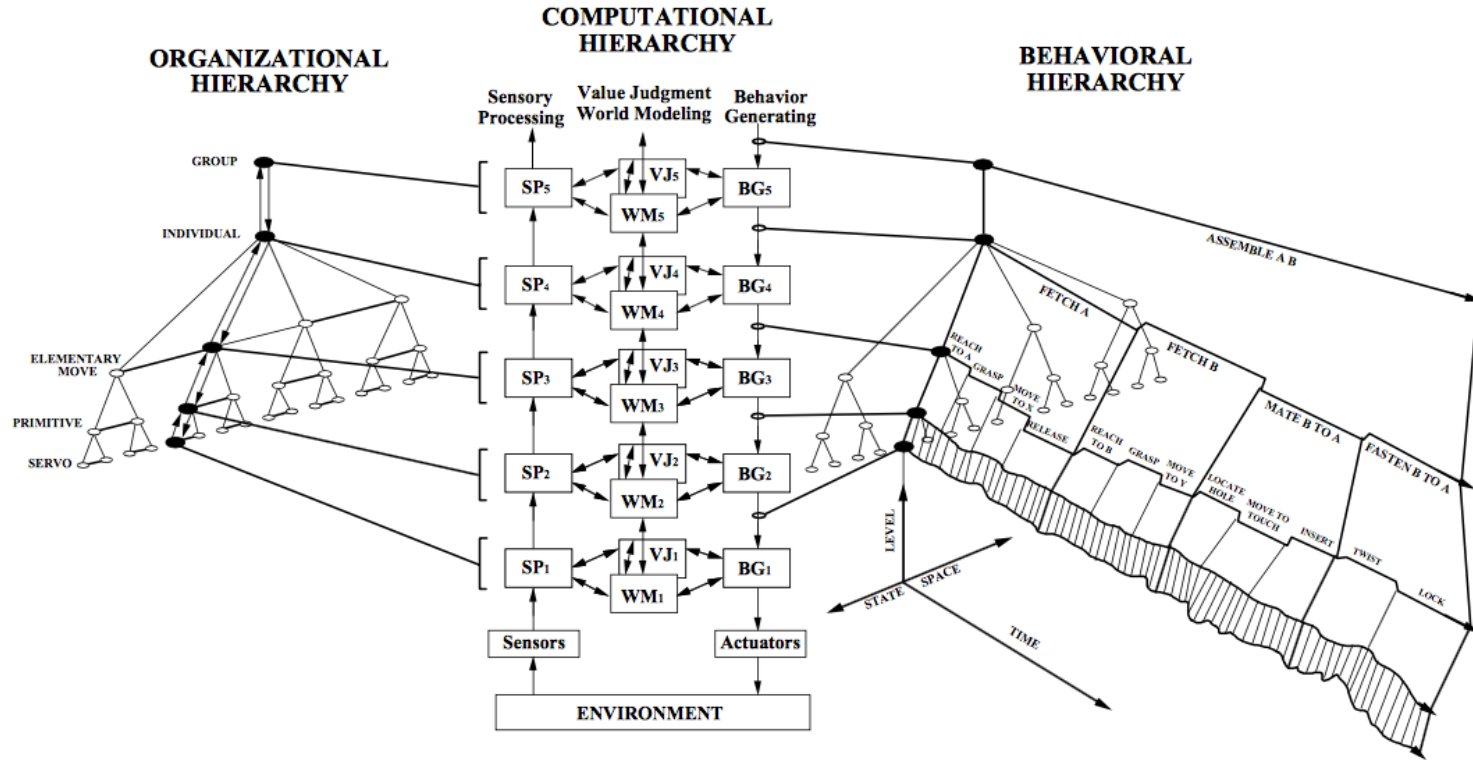
Architecture al la NeoCortex



- About the size of a large dinner napkin
- About 6 business cards thick
- Mountcastle – columnar organisation and uniform
- Hawkins – cortical hierarchy

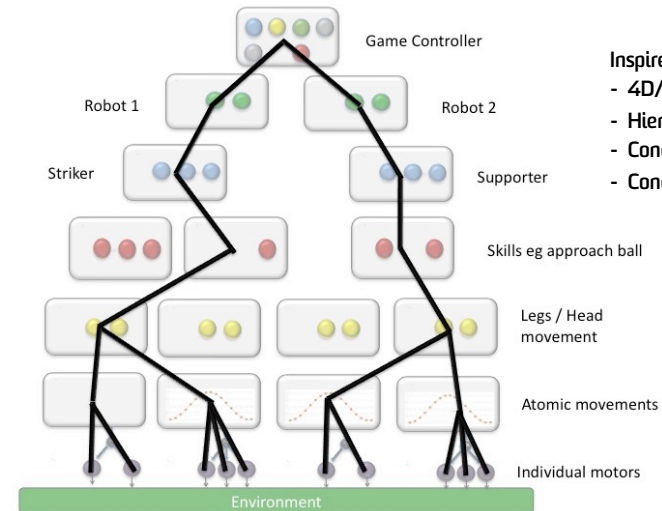
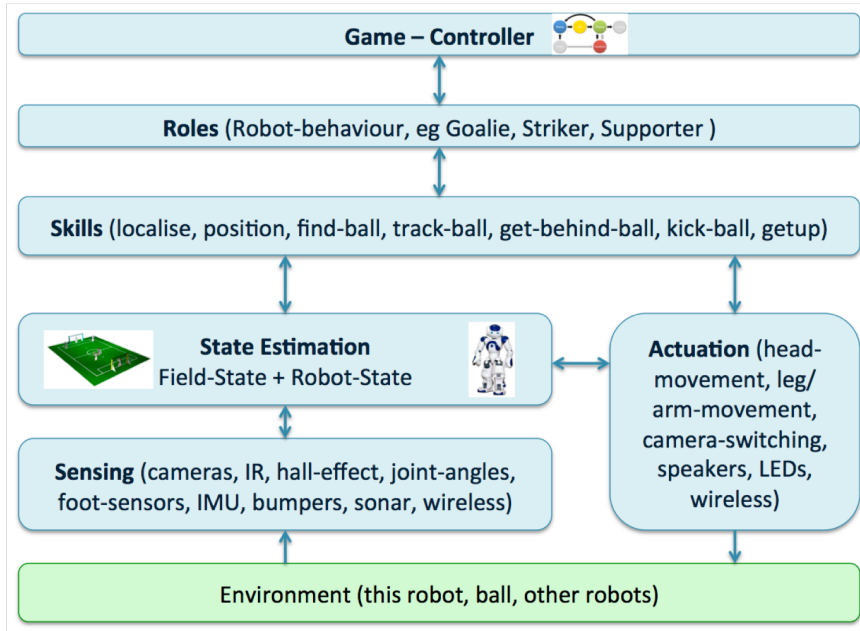


4D/RCS Reference Model Architecture



Engineering of Mind - Albus, Meystel 2001

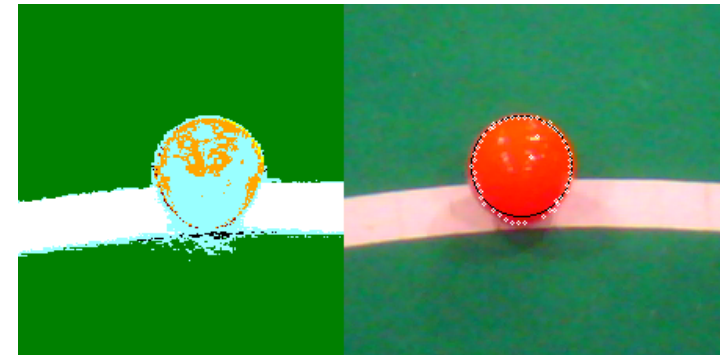
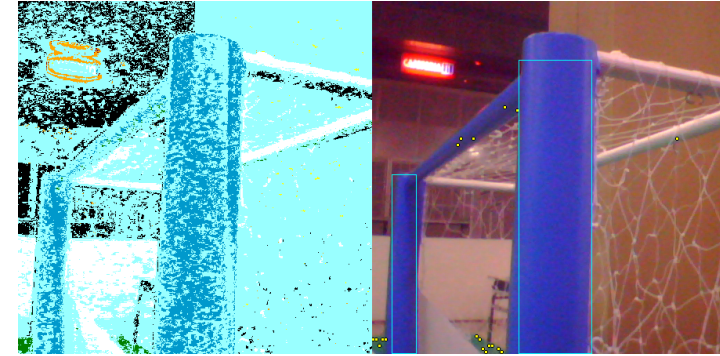
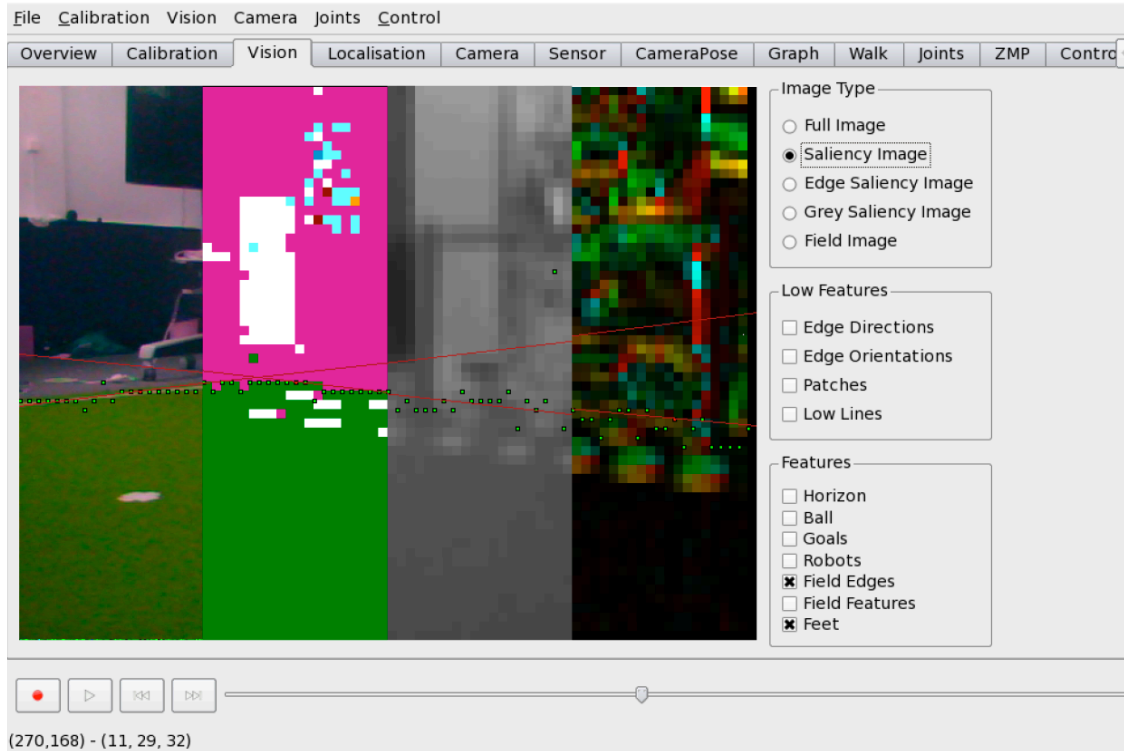
Robot Architecture



Inspired by:

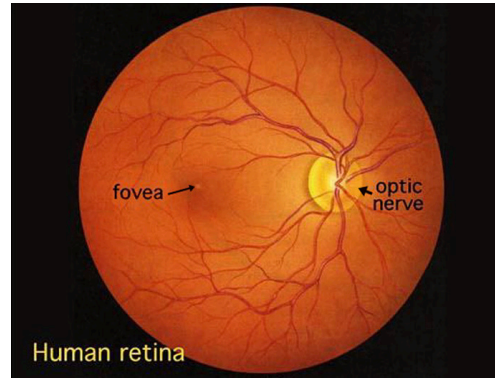
- 4D/RCS
- Hierarchical Finite State Machines
- Concurrent Task Hierarchy (HRL)
- Concurrent Teleo-Reactive Program

Less Colour Dependency

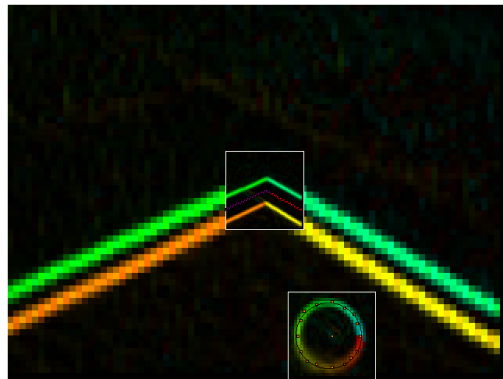


Adrian Rater 2010

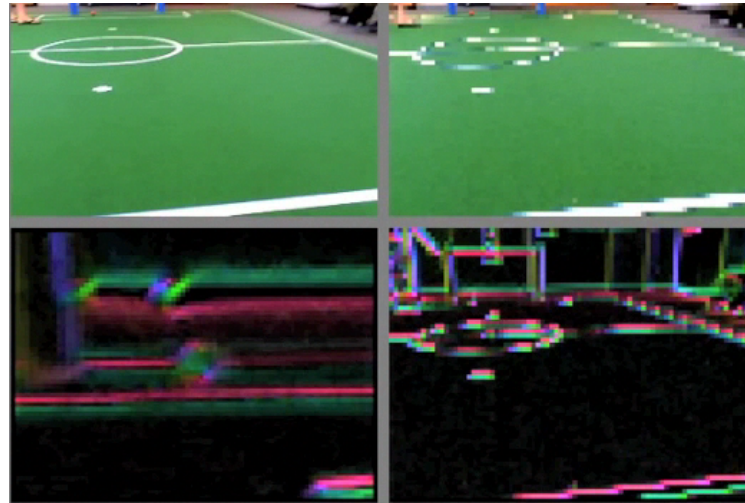
Foveated Vision and Virtual Saccades



Human retina
Webvision – Helga Kolb



Field-corner and Ball Foveas – Chatfield/Harris/Hengst



Foveated Ball Tracking – B Hengst 2011

Vision Saliency Preprocess

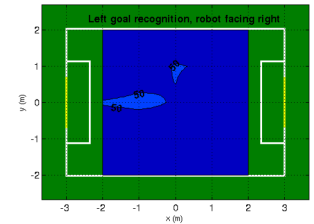
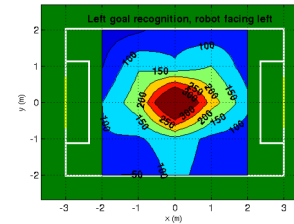
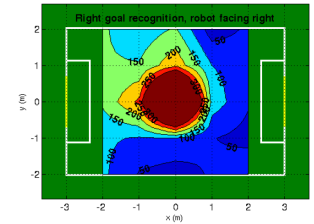
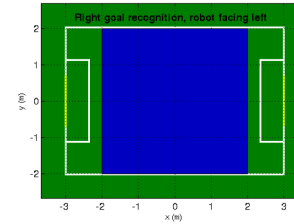
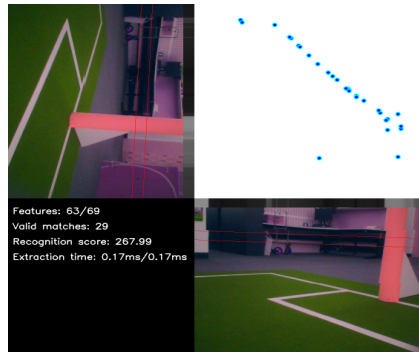
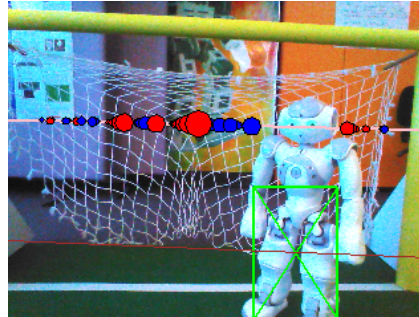
- Subsample and classify 640 x 480 image down to 160 x 120 (80 x 60)
- By processing every 4th (8th) pixel in the image, both vert. & horiz.
- This gives us information about the field edge, ball and goal locations

A diagram illustrating the Vision Saliency Preprocess. It shows a soccer field with a ball and goal locations. The field is divided into a grid of pixels. A red arrow points from the field to a smaller version of the field, which is then processed to extract saliency information. The resulting saliency map shows the field edge, ball, and goal locations.

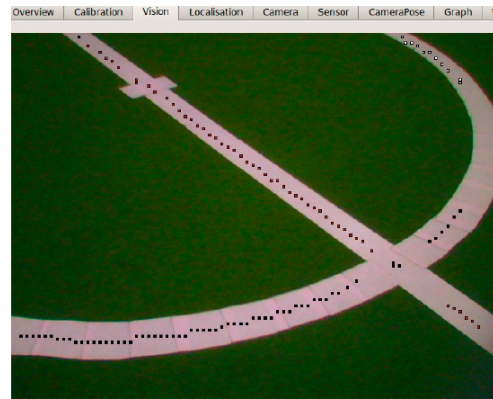
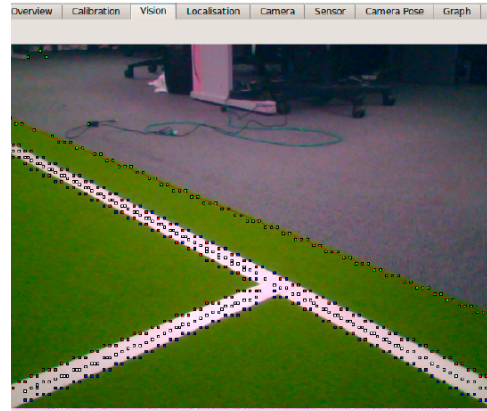
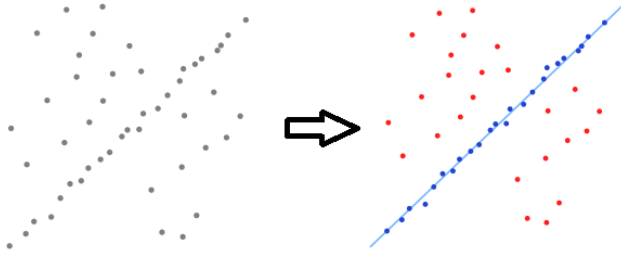
Storyboard – B Hengst 2010

Natural Landmarks – 1D SURF

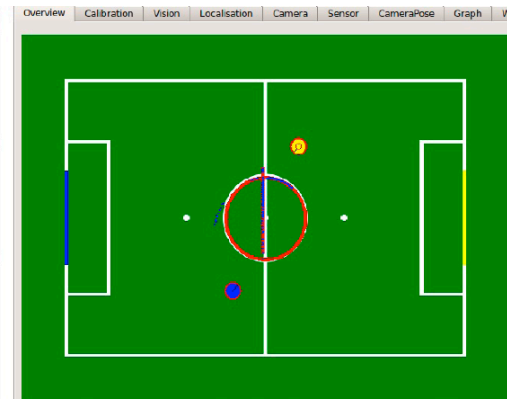
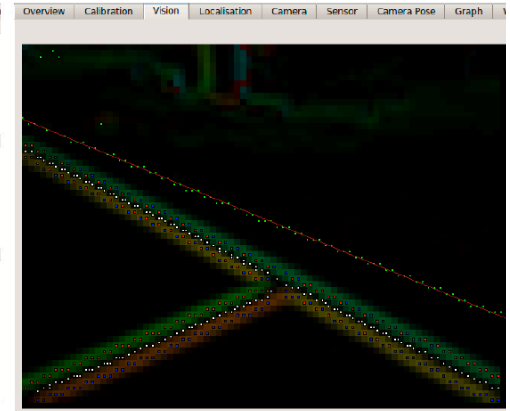
Peter Anderson 2013



Field-edge and Corner Features



Field-Line Detection – Sean Harris 2012



ICP Inspired KF Observation Updates

Peter Anderson 2013



Robot observations and pose estimate **Colour-classified robot camera feed**

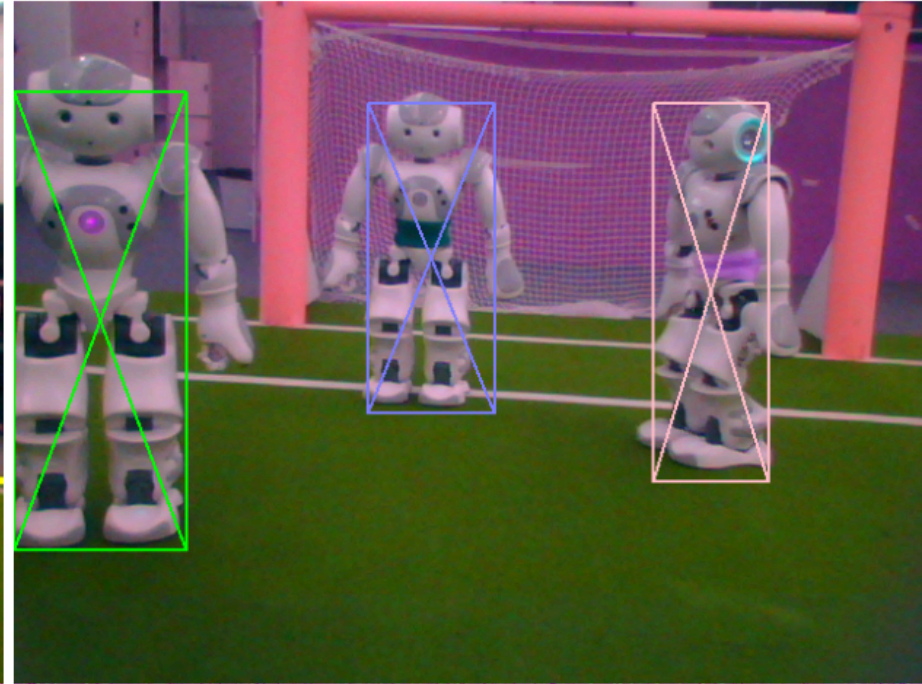
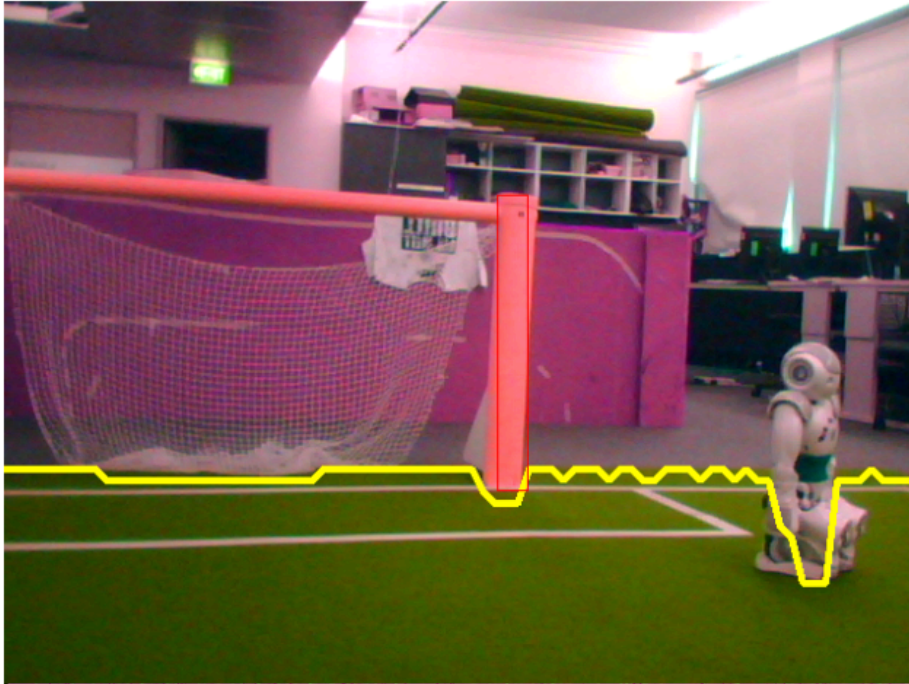


Robot pose estimate **ICP sensor model pose observation**

Alternative robot pose **Projected field-feature observations**

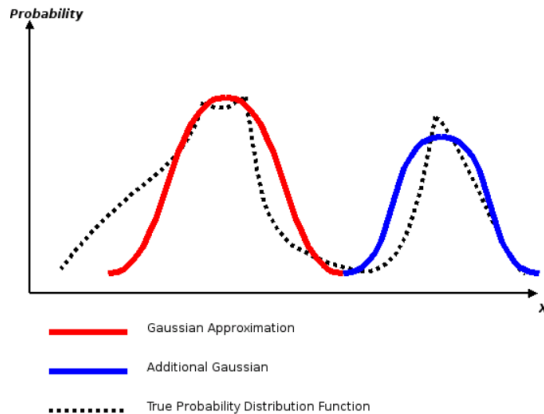
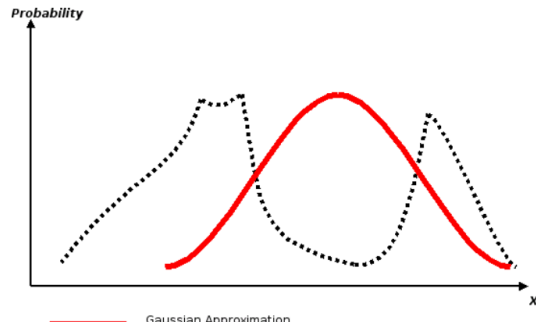
Robot Detection – Naïve Bayesian Classifier

Ashmore, J.: Robot detection using Bayesian machine learning (2014), UNSW CSE RoboCup Report



Localisation – Distributed Multi-Modal Kalman Filter

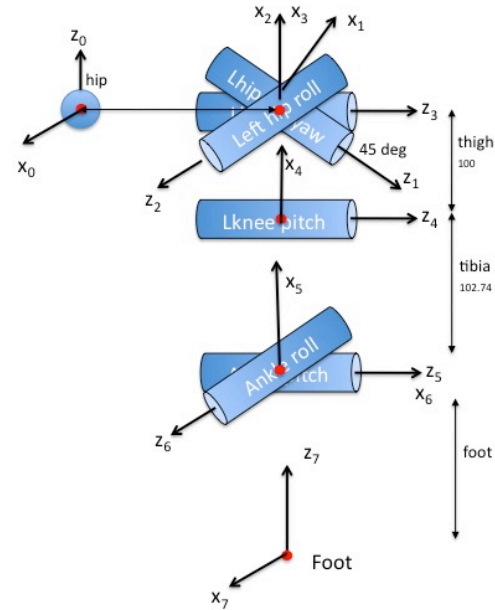
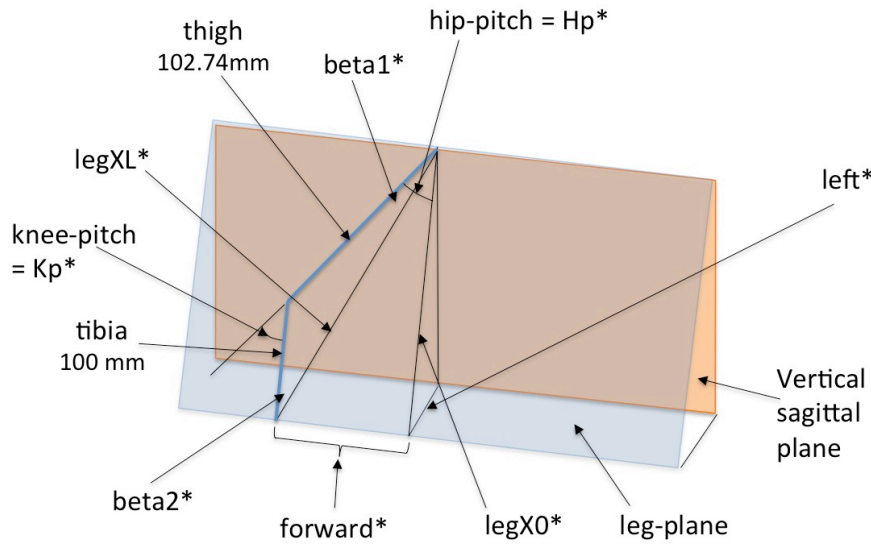
Sushkov, O.: Robot localisation using a distributed multi-modal Kalman Filter, and friends (2006), UNSW CSE RoboCup Report



MeanVector =

$$\begin{pmatrix} robot\ xpos \\ robot\ ypos \\ robot\ theta \\ ball\ xpos \\ ball\ ypos \\ ball\ dx \\ ball\ dy \\ teammate_1\ xpos \\ teammate_1\ ypos \\ teammate_1\ theta \\ \vdots \\ teammate_3\ xpos \\ teammate_3\ ypos \\ teammate_3\ theta \end{pmatrix}$$

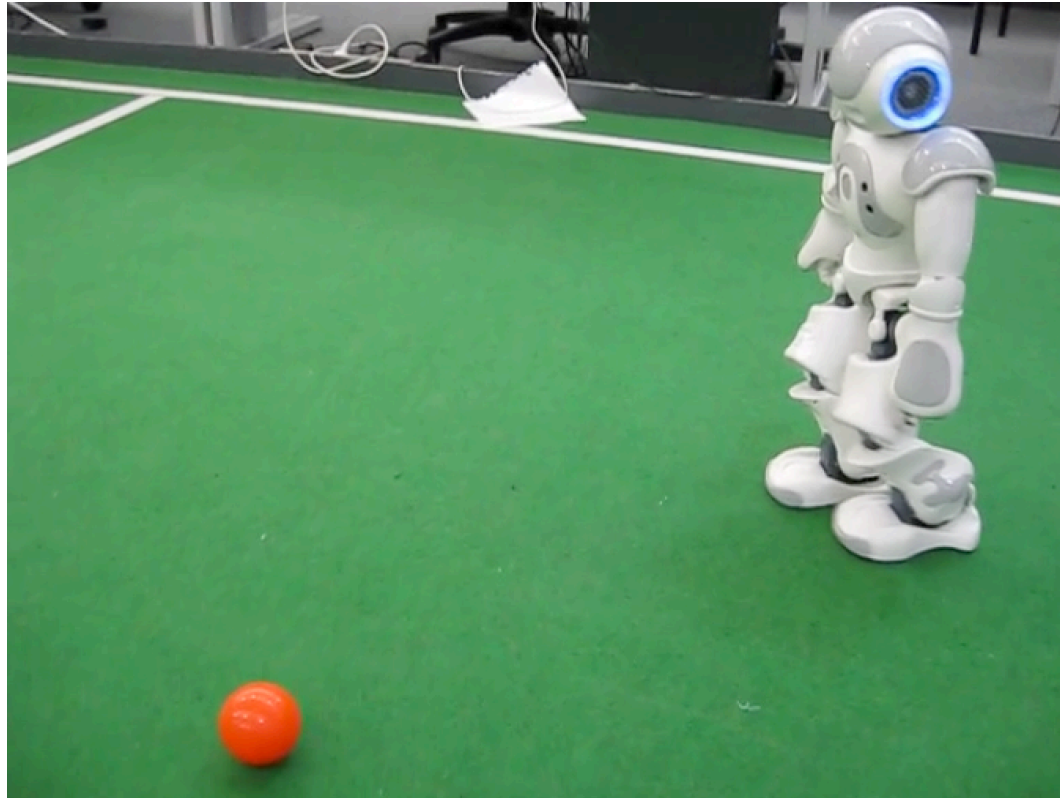
Locomotion - Kinematics



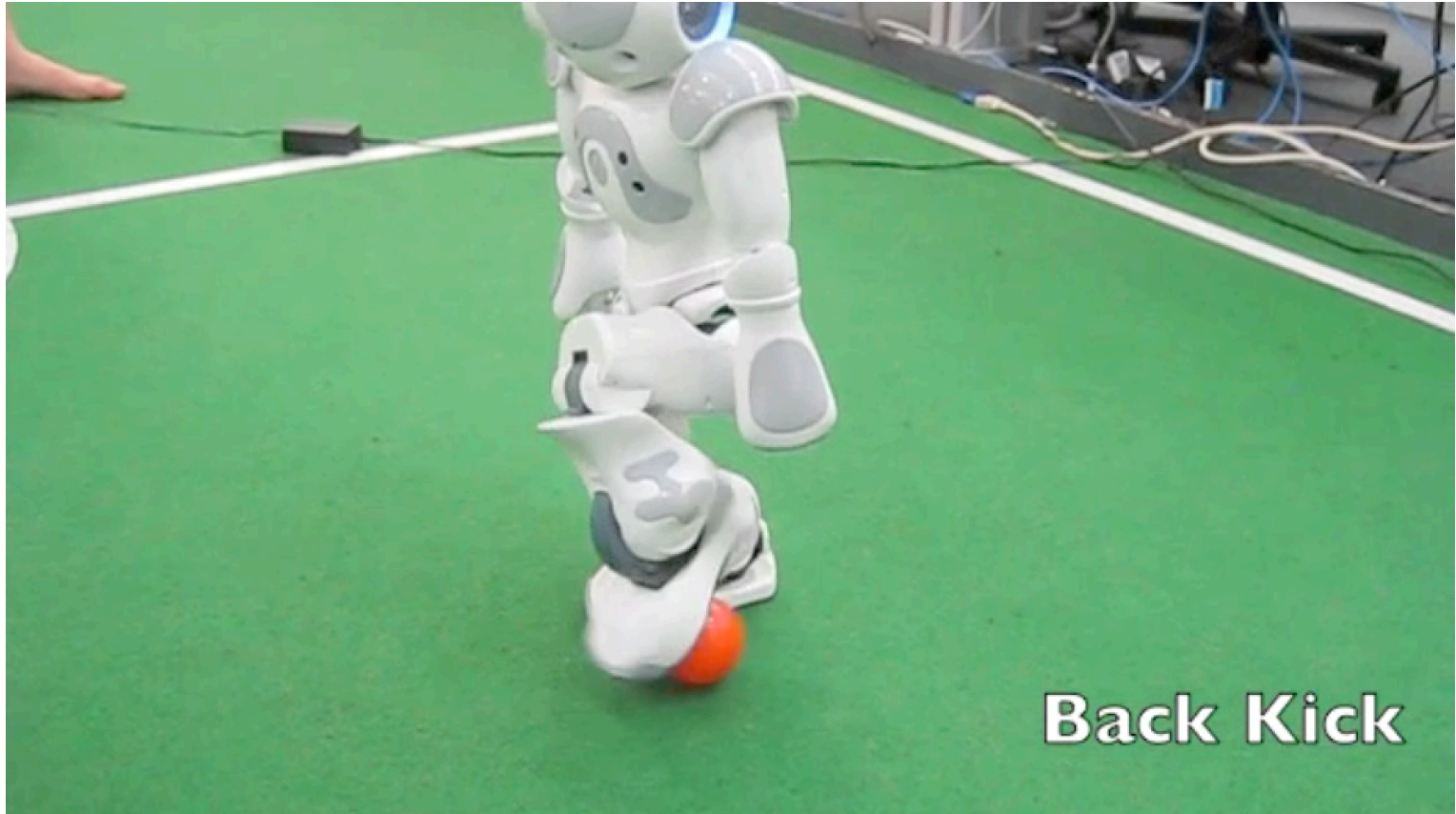
mDH transform parameters for Nao (Left ankle to Left hip)
10th Feb 2009 BH

Joints	$a[i-1]$	$\alpha[i-1]$	$d[i]$	$\Theta[i]$
0				
1	0	$-3 \cdot \pi/4$	0	$-\pi/2 + H_p$
2	0	$-\pi/2$	0	$\pi\pi/4 + H_r$
3	0	$\pi/2$	0	$0 + H_p$
4	-thigh	0	0	$0 + K_p$
5	-tibia	0	0	$0 + A_p$
6	0	$-\pi/2$	0	$-\pi/2 + A_r$
7	0	$-\pi/2$	0	$-\pi/2$

Locomotion – “SlowWalk”



Locomotion - Kicks



Back Kick

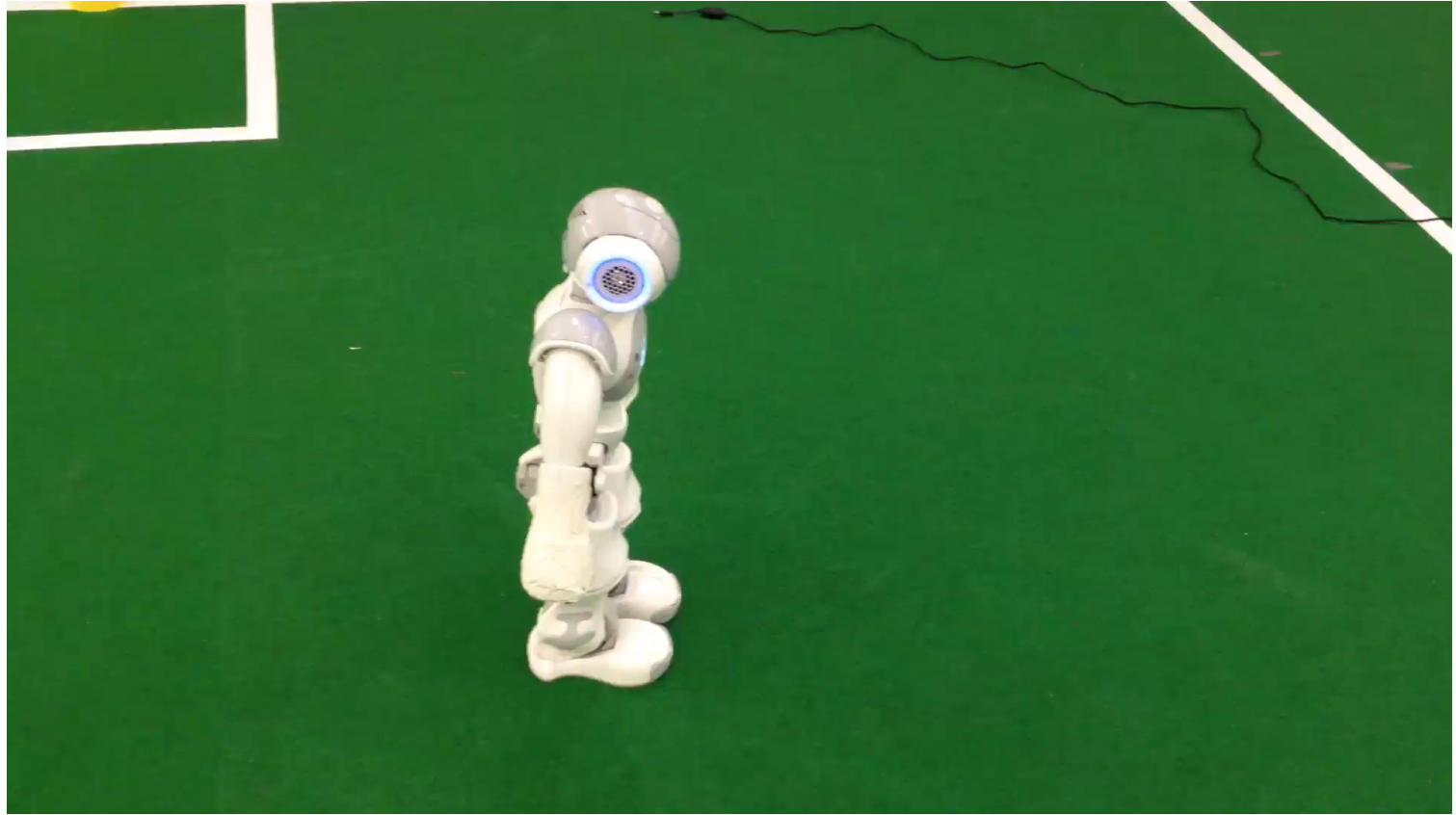
Turn-Kick

Teh, Belinda: Dynamic omnidirectional kicks on humanoid robots (2012), UNSW CSE RoboCup Report



UNSW vs HTWK (2014)

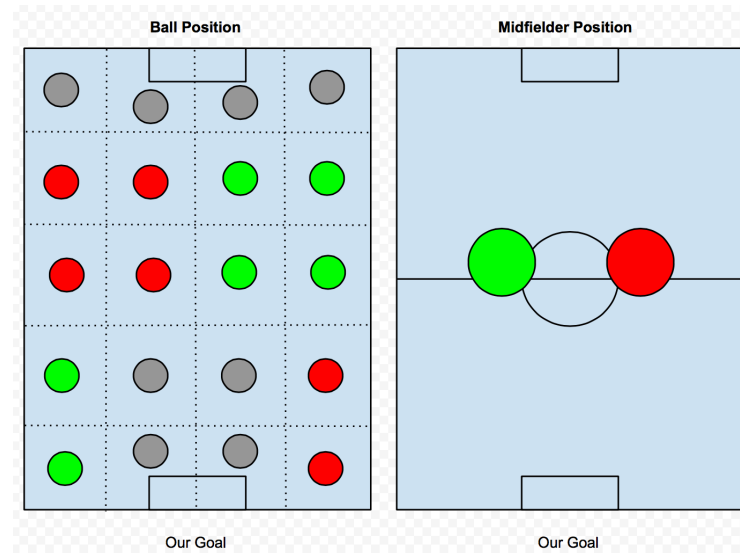
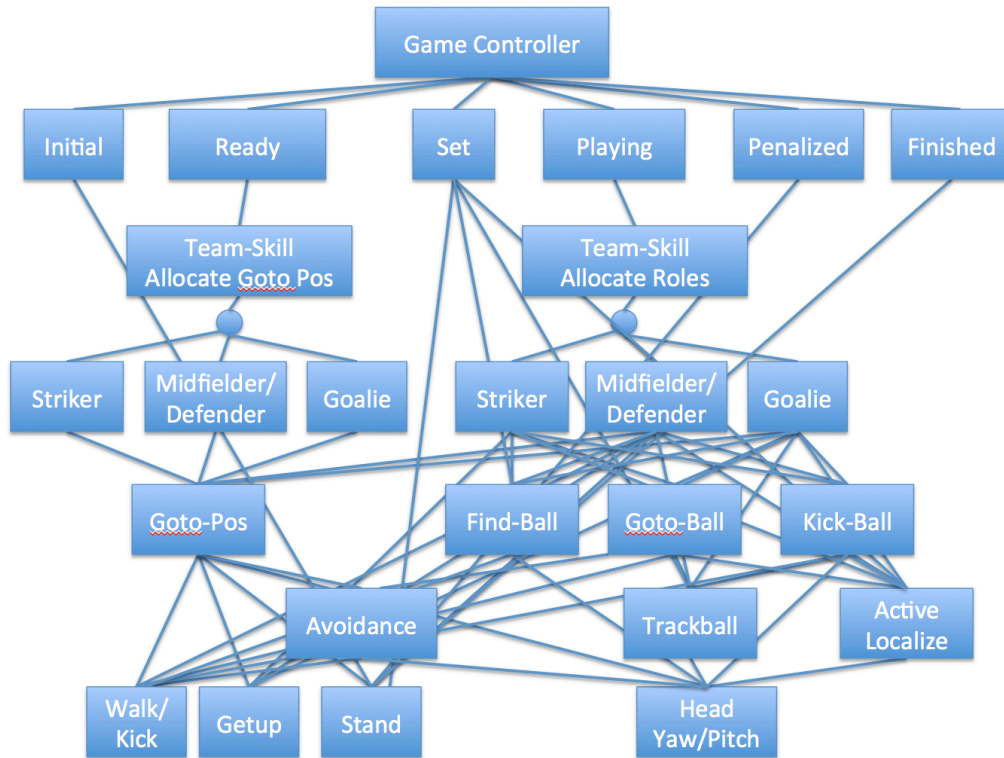
Walk Test 2014



Chasing Ball and Kicking with Left Foot



Roles and Skills



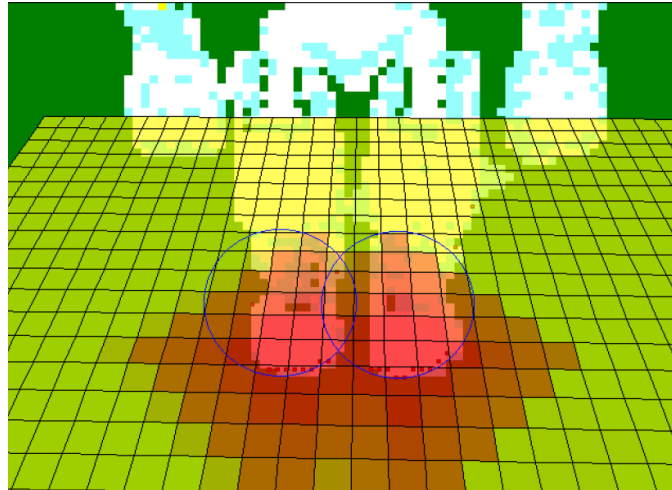
Oleg Sushkov 2014

2015 Developments

- Whistle detection
- Foot detection
- White goals



Peter Schmidt - 2015



Luke Pearson - 2015



Kenneth Ng - 2015

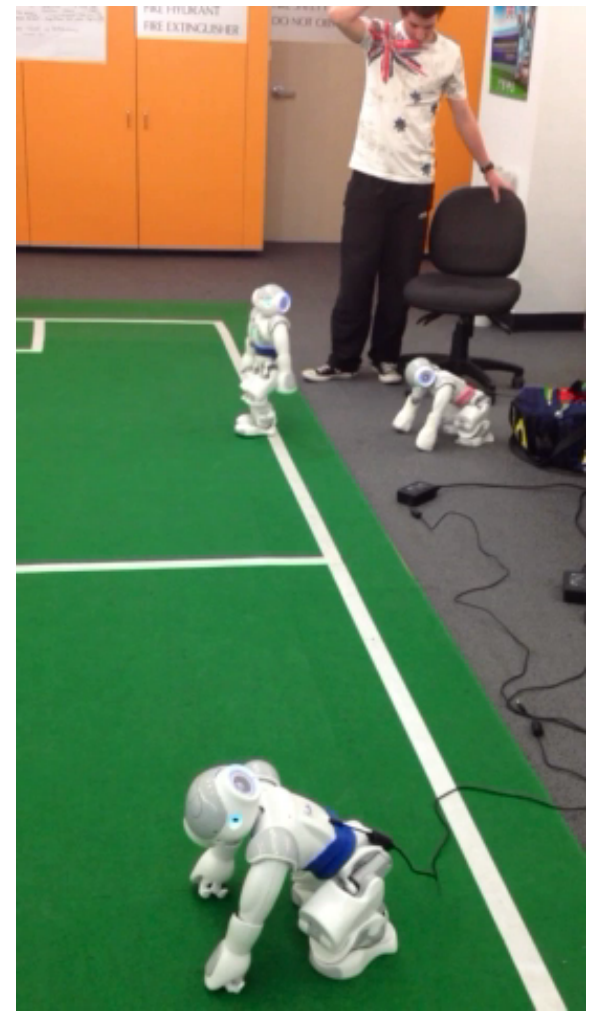
Team Organisation

- Undergraduate project
- Selection criteria
- Early exposure
- Story-board strategy
- Practice eg kicking goal
- Weekly review
- Communication
- Institutional support



Luke Pearson - 2015

Solo Benchmark



Acknowledgements

The camaraderie and assistance from other SPL teams and RoboCup



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