RoboEireann Team Description for RoboCup Standard Platform League 2013

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1 Team

1.1 Team Leader

Thomas Whelan (Software Lead) http://www.cs.nuim.ie/users/mr-thomas-whelan
Rudi Villing (Academic Lead) http://www.eeng.nuim.ie/~rvilling/

1.2 Academic Team Members

The team combines researchers from the Computer Science and Electronic Engineering departments with support from the Hamilton Institute at NUI Maynooth. Academic team members and research interests are described below.

Name	Department	Research Interests
Dr Rudi Villing	EE	Signals, Perception & Embedded Software
Mr John McDonald	CS	Vision & Image processing
Dr Sean Mcloone	EE	Intelligent Systems & Control
Dr Adam Winstanley	CS	Intelligent Systems & Signal Processing
Dr Robert Lawlor	EE	Signal Processing
Dr Diarmuid O'Donoghue	CS	Analogical Algorithms, Genetic Optimisation
Prof Barak Pearlmutter	CS/Hamilton	The Brain & Computation, Machine Learning

1.3 Student Team Members

Name	Degree	Project
Tom Whelan	Ph. D. (CS)	Vision, Localisation
Aodhan Coffey	Ph. D. (EE)	Infrastructure, Behaviour
Donagh Hatton	Ph. D. (CS)	Behaviour, Tools
Simon Fuller	Ph. D. (CS)	Probabilistic modelling
Damien Kearney	Ph. D. (EE)	Biomechanics, motion
Jin Jialei	B. Sc. (CS)	Vision

1.4 Robot Team

The primary robot team currently consists of two H21 V4 Nao robots and four H21 V3.3 Nao robot bodies with V4 head upgrades. We have four additional H21 V3.3 Nao robots as well as a deprecated V3 Nao robot we do not expect to bring to competition.

2 Team Progress, Interests, and Planned Activities

2.1 Background

In 2008, we were part of the joint Newcastle/Maynooth team, *NUManoids*, who won the world championship. Since that time we have competed as an individual team. In 2010, we competed in the German Open and came 6th out of 12 teams, in 2011 came 4th out of 12 teams and in 2012 came 2nd out of 14 teams. In addition, our Open Challenge "Localisation without goal posts" was voted 1st place at RoboCup 2011 Istanbul.

2.2 Robot Perception

Vision in the RoboCup environment presents many key challenges. Computational performance of a vision system is always a principle concern in any RoboCup league and as a result we have exploited as much of the hardware CPU capabilities as possible, including the use of assembly and MMX instructions [1].

One significant issue with the rapidly moving cameras on board the Nao platform is that of rolling shutter, a topic which the team has developed a means of alleviation in the past [2]. We also have algorithms based on optimisation working in the HSI space for captured images. The system seeks the optimal HSI space bounds for each colour to minimise a compromise of false alarms and misses in colour segmentation. This is then used to generate a look up table in the robot colour space for colour segmentation [3].

In addition to this we have developed techniques for automatic camera setting calibration based on genetic optimisation of camera parameters with a fitness function designed to maximise the difference between all colors of interest. This is similar to the approach taken by Grillo et al. [4].

We also have preliminary experience with image correlation based algorithms for line/goal detection [5]. Image correlations have the advantage of being highly robust to noise and occlusions in classifying fixed field objects.

We have successfully examined techniques based on Cox's algorithm that obviate the need for line determination and clustering [6]. Cox's algorithm, effectively an early variant of the iterative closest point (ICP) algorithm, has been used by the team with great success in two RoboCup events. A highly optimised implementation coupled with a novel means of determining point correspondences (via a precomputed voronoi diagram) makes the technique not only robust but also computationally feasible [1].

We are currently researching approaches that enhance localisation through the use visual cues from static elements of the environment surrounding and above the pitch. Here we are attempting to build a visual map of the pitch surrounding that can be efficiently indexed and matched against. We foresee this approach being particularly important in providing an absolute frame of reference that can be used in correcting situations where the robot gets disorientated (e.g. due to falling over or kidnapped robot scenarios).

2.3 Motion

Walking Since RoboCup 2011 we have been using a modified version of the 2010 B-Human walk [7]. The B-Human walk engine was extracted from the B-Human code release and integrated into our own code base.

Kicks Our kick engine was designed around carefully designed poses for backswing, mid strike, foot lift and recovery. In all cases, key aspects of torso, arm and leg movements were considered in the design. The basic design consisted of a small number of main kick designs: (i) Ball in front of right foot; kick straight ahead with right foot; (ii) Ball in front of left foot, kick with right foot, to the left. (iii) Ball to the right of the right foot, kick straight ahead.

In addition, by interpolating between different kicks, we could, within a range of placement of the ball, independently specify direction of the kick. Tests, in the laboratory, at RoboCup in Graz, Singapore, Istanbul, and also at the German Opens showed that we could kick more than the length of the field.

Balance We have recently introduced a basic balance engine. This balance engine can compute a static balance solution for any feasible target leg position relative to the current support foot. Balance is achieved by moving the torso and adjusting the target foot position (relative to the torso) to compensate for the constrained hip-yaw-pitch joint of the Nao robot. This version of the balance engine also allows the target leg to move through simple trajectories and computes the required joint configuration to ensure the robot remains statically balanced throughout.

2.4 Localisation and World Modeling

Our localisation has been mostly based on a single model unscented Kalman filter (UKF), however we have evaluated alternative approaches including Particle Filtering [1], [6]. Recent changes to this have included a covariance intersection (CI) version of this algorithm. The CI version removes the traditional independent noise assumption of the Kalman Filter, and thereby gives better robustness to correlated measurement errors. Related past publications from the team include [8], [9] with our most recent localisation system described in [6] and [1].

We also recently developed a number of techniques to overcome the symmetric field problem introduced by the 2012 SPL rule change to uniformly colored goals. Rather than taking a heuristic approach we simply allow the UKF to evaluate the probability of the observed posts given the robot's current estimate and chose the most likely possibility. This can be seen as splitting the model (two ways for a two post perception and four ways for a single post perception) and chosing the most likely based on the current estimate. We found at the 2012 German Open that this approach worked well for us as our "local" localisation is typically quite strong due to the method we integrate white field marking perceptions into the UKF [1]. However there are always points at which robot kidnappings occur. For this reason we introduced a shared world model that allows an agent to "flip" their world estimate given information from team mates. If an agent's estimate of the ball location is not consistent with two or more ball locations reported by other agents, the ball location is evaluated as if the world model was flipped. If this flipped world model is consistent with the location shared by many other agents, the flipped world model is accepted as correct.

2.5 Behaviour and Team Play

Behaviour and team play have been the subject of recent work. We are currently using an early "alpha" variant of the b-script behaviour engine [10] to specify our behaviours. In order to execute cooperative team play we have developed a behaviour system whereby each agent determines their own role based on information they perceive themselves and information broadcast from their team members. Under four player SPL rules we typically have four roles: Striker, Supporter, Defender and Goalie.

3 Planned activities

Prior to RoboCup 2013, we plan to focus on a number of key areas. First, we are porting our current code to the Nao V4 robots. In addition to tuning the code for the new platform, we are intent on utilising the increased computational resources to improve vision, perception, planning, locomotion, and world modelling. We intend to add to our existing behaviours to account for various situations we encountered in competition, to account for rule changes, and to provide more intelligent and robust gameplay in general. We plan to work on improvements to the speed of our kick targeting (without sacrificing its current accuracy). Finally, we would like to enhance the balance engine and use this as a foundation for a wider range of kicks and motions.

4 Conclusion and Outlook

Since competing in RoboCup 2011 we have overcome the challenging introduction of uniformly colored goals with a solution proven to be robust and consistent as demonstrated by our 2nd place achievement in the 2012 GermanOpen. Although we were unable to attend RoboCup 2012, the team is eager to resume competition on the international stage and fully committed to participation in RoboCup 2013.

References

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