System Design Project, Group 11, Report 2

The following report describes our progress towards creating a Lego robot that can play robocup football. It also summarises our attainment of Milestone 2, which required our current robot to be able to navigate to a static ball on an empty pitch. Reaching this milestone involved developing several aspects of our program, while making further improvements to our robot's design.

Progress Summary

Area	Target Aim for Milestone 2	Status at Milestone 2	Assessment
Vision	Accurately report position and orientation of robots, and position of the ball.	Accurately reports position and orientation of robots, and position of the ball. Corrects barrel/perspective distortion, which greatly helps accuracy.	Ahead of target
Planning/ Strategy	Calculate a movement plan that will navigate the robot to the ball.	Calculates a movement plan that will navigate the robot to the correct side of the ball for shooting. Plan avoids an obstructing opposition robot. Plan is also adaptive, continuously refined for changing conditions and uses the kicker appropriately.	Ahead of target
Movement	Issue appropriate motor commands for the physical robot to achieve the plan.	Issues appropriate motor commands for the physical robot to achieve the plan.	On target
Robot Design	Construct a stable robot that can navigate in a straight line and turns correctly.	Robot is stable and navigates correctly, incorporating an accessible NXT brick, touch sensors, and a strong kicker.	Ahead of target
Integration	Program a methodical design, that integrates these components efficiently.	Program consists of a modular structure, where individual modules may be distributed across different machines, and may be updated and tested on-the-fly, without restarting the whole system.	Ahead of target

Robot Design

The main change in our robot's design, since the Milestone 1 demonstration, has been the adoption of a square chassis. This is slightly shorter than our previous rectangular chassis, by approximately one 'Lego unit.' The reduction in length has allowed us to lengthen the sides of our kicker, giving our robot better control of the ball while turning. An additional advantage from the square design is that it gives a better weight balance on the supporting ball bearings, which has improved stability.

We found the position of the touch sensor to be sub-optimal. Many front-corner collisions were not detected, as the sensor, located in the centre of the kicker, would not be triggered. Refining the design to use two touch sensors, located at the sides of the kicker, has vastly improved collision detection of obstacles not directly in front of the robot, without sacrificing any previous detection performance. The positions of the motors and NXT brick have also been altered, improving accessibility to the NXT buttons.

Programming

Our modular system has facilitated rapid progress. Having examined a less modular approach, we found that if certain functionality failed, the whole system would have to be restarted. Also, our resources would have been limited to one machine. Our approach brings the advantages of distribution of processing resources and reloading of updated modules on-the-fly. The integration sequence involves first loading the central knowledge server module, which coordinates communication between modules using TCP socket connections. Our other modules are then loaded and output their results to the knowledge server, which sends these to listening modules.

In planning, our robot can now navigate to a static or moving ball, on the correct side for shooting, and kick it into the goal. It recognises an opposing robot, plotting a path to avoid it. The planner is adaptive, continuously refining the plan with new vision data. Strategy for when the opposing robot has possession of the ball will soon be implemented.

The movement module alters the robot's speed according to distance from the objective. These alterations prevent miscontrolling the ball, but further testing is required to make sure the robot moves at the optimum velocity; these tests will improve our competitiveness. A PID controller is under development to alter motor power using movement errors, helping movement accuracy.

Our vision system reports the coordinates and orientation of the robots and the ball. Both barrel and perspective distortion are corrected from the camera source. Perspective distortion is caused by the camera's position at the centre of the pitch, causing objects near the goals to appear smaller than objects in the middle. The system compensates for this based on object distance from the centre of the pitch. Barrel distortion results in the pitch, and objects on it, appearing curved depending on their position; the camera's lens causes this effect. We have calibrated our system to compensate for this distortion, using a chequerboard pattern held in certain positions over the pitch to determine the overall barrelling effect. Compensating for these distortions allows us to calculate accurate estimates for the positions of the robots and ball, which means our planning module has more accurate information and can make more appropriate choices.

Making changes to the vision system caused us to devise a better way to test it than using live camera footage. A database of images has been constructed, with the robots and ball in varied, staged positions. The images are each accompanied by an XML document, containing manually entered positions and orientations. Images with respective XML are produced daily. Now, when the vision system is tweaked, it can be comprehensively tested in seconds. As more images are added to the database, our knowledge of the vision system's performance improves.

Our planning and movement are tested using our simulator. Having now implemented a kicker, the simulator will be further improved by determining more accurate physical parameters.

Group Organisation

Overall, the group continues to work efficiently and productively. The loss of Sameed, who dropped the course, increased the workload for the rest. Already being ahead of the first milestone has managed the effects. We co-ordinate through email and continue to program to no particular paradigms, not having felt the need to adopt one. However, we have adopted a general process of building the simplest solution, then refining and adding complexity. This ensures we achieve the milestone before trying to get ahead in certain areas. All group members choose their tasks and work in areas they feel comfortable with, which currently works well, owing to our wide range of talents. It remains to be seen whether working this way will continue to be appropriate for us.

Milestone 2 Demonstration

We began our demonstration with a presentation of our planning system, using our visualizer to display our vision information with the calculated movement plan overlaid, making it clear how the robot would reach the ball on the correct side for shooting. The movement module was then loaded, sending commands to the robot, which proceeded to follow the devised path. The visualizer continued to display the changing path as it was refined by the planner. On reaching the ball, on the correct side, the robot kicked it into the goal. The ball was then placed on the other side of the pitch, with an opposition robot in the way, and a plan to avoid the obstruction and reach the ball was automatically calculated and followed by the robot. The correction of distortions by our vision system was then presented. We concluded with an explanation of our system's modular structure and the associated advantages. Our demonstration was a success and went to plan, clearly exhibiting how our current project meets and exceeds Milestone 2.

Development Plan

Vision: Presently, our vision system usually processes about 17 frames per second. We will work to optimise this further, and also make alterations necessary for vision to work on the second pitch.

Planning: We must implement dribbling in order to attain Milestone 3. Additionally, we aim to intercept a moving ball and defend the goal appropriately. The paths currently devised are far from optimal, so these calculations will need to be refined to improve our competitiveness.

Movement: The next step is to implement backward motion. Presently, our movement commands are limited to moving forward and turning. These commands were the simplest solution to achieve this milestone, but will not be optimal for competitive matches. We will also need to implement appropriate functions for calculating movement commands along a smooth arc.

Robot Design: A rear touch sensor may be incorporated, but testing is required to evaluate the benefits of improved collision detection against the complexity of implementation, considering it would potentially increase the robot's physical dimensions beyond the permitted size. We wish to extend the kicker sideways to push on the touch sensors when a head-on collision occurs, and develop logic to disable the touch sensors when pulling the kicker back before shooting the ball.

Integration: Our modular structure is already in a refined state, coordinating individual modules which may be running on separate machines. Our overall test suite is relatively bare. More unit tests will be developed, to detect undesired behaviour in individual modules. We will investigate measures to improve latency; distributing modules over machines connected by wi-fi results in a relatively high ping time.

Conclusion

Our project is demonstrably ahead of Milestone 2. We have maintained our momentum from Milestone 1 and developed clear, achievable goals for the next two weeks. Group cohesion has been maintained despite the loss of a member. Having taken great strides in the past two weeks, we aim to achieve Milestone 3 quickly, so our system may go on to acquire a competitive edge.