Behavioral Strategies for Robotic Soccer

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In preparation for the 2014 RoboCup competition, Bowdoin's Northern Bites underwent a “Behaviors Overhaul.” In robotic soccer, behaviors are high-level strategies that determine what the robots do on the field given particular information from their environment. This includes tasks such as, where to look, where and how fast to walk based on information regarding the ball, what type of kick to do when close enough to the ball and much more. The majority of my summer research was spent contributing to the aforementioned Behaviors Overhaul.

My first project was to help compute the location of the “Shared Ball Model.” The Shared Ball Model allows robots that do not see the ball, rendering them less effective players, to listen to where their teammates see the ball and look for it there. I computed the location of the Shared Ball Model by using a simple weighted average of the ball distance estimates from each robot that could see the ball. The weight is inversely proportional to the distance a robot is to the ball. This allowed other programmers of the Northern Bites to design important strategies for finding the ball and positioning. The Shared Ball is also used to correct robots who think they are in a position symmetrically opposite the field of their actual location by determining if a player sees the ball in a symmetrically opposite position of where the other players see it.

Next I did research on more intelligent ways to approach a ball so that a robot could be lined up for a kick when it arrived at the ball. The former tactic was to walk straight to the ball and then orbit around the ball by sidestepping until the heading was correct, but orbiting was slow process. The most notable attempt was to walk a quadratic Bezier curve, a parametric equation in which x and y are both described by binomial polynomials with time varying from 0 to 1 and coefficients corresponding to the coordinates of the start, control, and end points. The point at time $= 0$ ($P_0$) was the robot and the point at time $= 1$ ($P_2$) was the ball. The control point ($P_1$) was calculated by projecting a line from the kick destination (usually the goal) through the ball and placing $P_1$ on this line, a fixed distance behind the ball. This curve would have the robot start on a path tangent to where it was facing and end tangent to the line connecting the ball and the kick destination. Using our current systems it is extremely difficult, perhaps mathematically impossible to walk to all of the arbitrary points on the curve accurately enough for this to work. Other attempts at intelligent ball approaches were more successful, however major changes in our kicking strategy reduced the need for faster approaches.

Perhaps the most important contribution I made this summer was my development in motion kicking. Our previous "Sweet Move" kicks were designed such that the walking engine would have to be turned off, the robot would enter the standing state and then it would go through the predetermined “key frames” until the motion was finished. Then the robot would stand again and re-enter the walk engine. This takes a considerable amount of time and the motions can often be unstable. Our new walking engine allows
for kicks to be executed during a step so that the robot can walk and kick at the same time. After reading the documentation on our walk engine I was able to implement 3 motion kicks, a front kick, a sideways kick, and a kick that went off to 45 degrees. These new kicks made us able to kick the ball much more quickly and in more control.

In the later part of the summer my behaviors work was spread across three smaller projects. The first was redesigning the strategies for the all too common situation of losing the ball. Different strategies were formed based on if it seemed like the ball rolled behind or to the side of the robot's vision, if the ball was obstructed at the feet of the robot, or if the ball was just too far to see. The second project was claiming the ball. As in real soccer, it is important that we don't have all of the players attacking the ball at the same time or they will be counter productive. I was able to improve our ability for a robot to determine when they should claim the ball and have teammate position in strategic positions based on the ball. The major issue was two players both wanting to claim the ball at the same time. I solved this by giving tiebreaks to the player with the better heading on the ball or the player who's role was more of an attacker based on a sigmoid function. The final project was kickoff set plays. The kickoff is the time in the game when our robots are best localized so they are able to most accurately kick the ball to a desired location here. I wrote a number of give-and-go plays that were designed so that the kickoff was a pass to a second robot that would then try to kick the ball in front of the goal where the first robot would chase the ball and try to score. These plays are still being developed.

The Northern Bites source code can be found at https://github.com/northern-bites/nbites

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