# SOME SITCALC FORMULAS FOR ROBOT SOCCER

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MAYBE DEAL WITH: more resolution of locations, some mental variables, failures, observations

There will be mainly formulas for now. Discussion will be gradually filled in.

## 1 A simple determinist model

Individuals in the ontology: robots, locations, the one ball, just one goal, situations.

$Near(l1, l2)$ means location $l1$ is near to location $l2$.

$Location(r, s)$ location of robot $r$ in situation $s$.

$HasBall(r, s)$ means $r$ has the ball in $s$.

$Faces(r, l)$ means robot $r$ faces location $l$.

$Face(r, l)$ action of facing $l$.

$KickBall(r)$ is the action of kicking the ball. It is effective only if the kicker has the ball.

$KickGoal$ is kicking a goal and then stopping. I'm not happy about its definition.

$Run(r,l)$
$Score(s)$
$Stop$

$$Near(L1,L2) \wedge Near(L2,Goal1) \wedge Near(L3,L2) \tag{1}$$

$$\begin{aligned} &Faces(r,l,Result(Face(r,l),s)) \\ &Faces(r,l,s) \rightarrow Location(r,Result(Run(r,l),s)) = l \end{aligned} \tag{2}$$

$$Location(r,s) = Location(Ball,s) \rightarrow HasBall(r,Result(Grab,s)) \tag{3}$$

$$\begin{aligned} HasBall(r,s) &\rightarrow Location(Ball,Result(KickBall,r1,s)) = L1 \\ \vee &Location(Ball,Result(KickBall,r1,s)) = L2 \\ \vee &Location(Ball,Result(KickBall,r1,s)) = L3 \\ \vee &Location(Ball,Result(KickBall,r1,s)) = Goal1 \end{aligned} \tag{4}$$

$$\begin{aligned} &Near(Location(r,s),l) \wedge HasBall(r,s) \wedge Faces(r,l,s) \wedge Location(r2,s) = l \\ &\rightarrow Location(Ball,Result(KickBall(r),s)) = l, \\ \\ &Near(Location(r,s),Goal1) \wedge HasBall(r,s) \wedge Faces(r,Goal1,s) \\ &\rightarrow Score(Result(KickGoal(r),s)) = Score(s) + 1 \\ &\qquad \wedge Stopped(Result(KickGoal(r),s)) \end{aligned} \tag{5}$$

$$\begin{aligned} &Occurs(e,s) \rightarrow Next(s) = Result(e,s) \\ &Next^*(s) = \textbf{if } Stopped(s) \textbf{ then } s \textbf{ else } Next^*(Next(s)). \end{aligned} \tag{6}$$

$$\begin{aligned} &(\forall r)(Location(r,S0) = L1 \vee Location(r,S0) = L2 \vee Location(r,S0) = L3) \\ &Location(Ball,S0) = L1 \vee Location(Ball,S0) = L2 \vee Location(Ball,S0) = L3. \end{aligned} \tag{7}$$

How can we extend the logical formalism so it will accept the more human-like

$$(\forall x \in Robots \cup \{Ball\})(Location(x,S0) = L1\ Or\ L2\ Or\ L3))? \tag{8}$$

Here's a "strategy" expressed in terms of occurrence axioms.

$$
\begin{aligned}
&\quad Occurs( \\
&\textbf{if } Location(R1, S0) = Location(Ball, S0) \\
&\ \textbf{then } GrabBall(R1) \\
&\textbf{else } Run(R1, Location(Ball, S0)), s), \\
\\
&\quad HasBall(R1, s) \rightarrow Occurs( \\
&\textbf{if } Location(R2, s) = L2 \textbf{ then} \\
&\qquad (\textbf{if } Facing(R1, Location(R2, s)) \\
&\qquad \textbf{then } KickBall(R1)) \\
&\qquad \textbf{else } Faces(R1, L2)) \\
&\textbf{else } Run(R2, L2), s) \\
\\
&\quad HasBall(r, s) \wedge Location(r, s) = L2 \wedge \neg Faces(r, Goal1, s) \\
&\rightarrow Occurs(Face(r, Goal1), s), \\
&\quad Location(Ball, s) = Location(r, s) = L2 \wedge \neg HasBall(r, s) \\
&\rightarrow GrabBall(r), s), \\
&\quad (Location(r, s) = L2 \wedge HasBall(r, s) \wedge Faces(r, Goal1, s) \\
&\rightarrow Occurs(KickGoal(r), s).
\end{aligned}
\tag{9}
$$

Two of these formulas use imbedded conditional expressions.[1]
Proving

$$
Score(Next^*(S0)) = Score(S0) + 1 \tag{11}
$$

[1] They are equivalent to the following five formulas.

$$
\begin{aligned}
&\quad Location(R1, S0) \neq Location(Ball, S0) \\
&\rightarrow Occurs(Run(R1, Location(Ball, S0))), \\
&\quad Location(R1, s) = Location(Ball, s) \rightarrow Occurs(GrabBall(R1), s), \\
&\quad HasBall(R1, s) \wedge Location(R2, s) \neq L2 \\
&\rightarrow Occurs(Run(R2, L2), s), \\
&\quad HasBall(R1, s) \wedge \neg Facing(R1, Location(R2), s) \\
&\rightarrow Occurs(Faces(R1, Location(R2)), s), \\
&\quad HasBall(R1, s) \wedge Facing(R1, Location(R2, s), s) \\
&\rightarrow Occurs(KickBall(R1), s).
\end{aligned}
\tag{10}
$$

The conditional expressions avoid duplicate occurrences, and presumably duplicate evaluation, of the formulas occurring as conditions. However, only the presently defunct EKL interactive theorem prover allowed them as first class terms.

requires using unique names axioms and circumscribing certain formulas at each step of the sequence of events.

## 2 Extensions

These axioms assume that the result of each event is determined. Handling uncertainy requires a more elaborate theory. The *intended effect* of an action like $KickBall(r)$ is as described above, but we want to allow for other possible outcomes for this and other actions. A full theory would be quite elaborate, so we will only consider different effects of $KickBall(r)$.

The most conceptually familiar idea is to assign probabilities to the differentt outcomes and axiomatize this. The probabilities ought to vary with the player and the situation; a better player would be characterized by a higher probabillty that the ball would arrive at its nominal destination. The objection to the purely probabilistic approach is that there is no effective way of getting real probabilities. The harm from this is mitigated by the fact that the actual values of the probabilities may not matter very much.

A more realistic idea would be to assign a range of probabilities, e.g. with a good player $r$ having a probability in the range 0.8-0.95 of reaching the nominal destination with $KickBall(r)$.

In either case the strategy must be elaborated to deal with the ball ending elsewhere than its nominal destination. For example, the nearest robot may then run to the ball. Such an axiomatization should have some plausible grid of locations, not just $L1$, $L2$, and $L3$.

I favcr a yet weaker way of assigning plausibilities to the outcomes of events.

Some modification of the $Next(s)$ formalism is required, perhaps a parameter that depends on whether an event has its nominal effect.

More later.