Sports Simulation – Simple Soccer

Artificial Intelligence for
Interactive Media and Games

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[Based on Buckland, Chapter 4 and lecture by Robin Burke]

Plan for next three weeks (re Soccer)

- *Mon/Tues/Thu:* Simple Soccer Anatomy
- *Sun midnite:* "My Team" homework due [3 pt]
  - set up code to make modifications
  - *study game play carefully to look for improvements*
- *Mon:* In-class brainstorming
- *Weds midnite:* "Team Design" homework due [3 pt]
- *Weds 10pm:* "Tournament Team" due [10 pt]
  - 10/10 requires adding *substantial* new strategy
- *Thu Nov. 19:* Soccer tournament (KH 203)
  - final grade bonus points for winner and runner-up

Week	Day	Book	Lecture (with links to notes)	Homework (with links)
1	Tue, Oct 28		Intro/Overview/Admin	
	Wed, Oct 29			1 - Hello West World [3%]
	Thu, Oct 30	Chapter 2	State Machines	
	Fri, Oct 31	Chapter 2	Event Messages	
	Sun, Nov 2			2 - Bar Fly [5%]
⇨ 2	Mon, Nov 3	Chapter 4	Simple Soccer Anatomy	
	Tue, Nov 4	Chapter 4	Simple Soccer Anatomy	
	Wed, Nov 5			3 - Tank States [5%]
	Thu, Nov 6	Chapter 4	Simple Soccer Anatomy	
	Fri, Nov 7		**Futures:** AIIDE 2014 Conference Highlights	
	Sun, Nov 9			4 - My Team [3%]
3	Mon, Nov 10		**Brainstorming:** Simple Soccer Strategy	
	Tue, Nov 11	Chapter 6	LUA Scripting	
	Wed, Nov 12			5 - Team Design [3%]
	Thu, Nov 13	Chapter 6	LUA Scripting	
	Fri, Nov 14		**Futures:** Neuroevolution of Combat Bots	
	Sun, Nov 16			6 - Scripting [5%]
4	Mon, Nov 17	Chapter 7	Raven Anatomy	
	Tue, Nov 18	Chapter 7	Raven Anatomy	
	Wed, Nov 19		(Due 10pm!)	7 - Tournament Team [10%]
⇨	Thu, Nov 20		**Soccer Tournament** (KH 203)	
	Fri, Nov 21		**Futures:** TBD	
	Sun, Nov 23			8 - My Bot [3%]

Simple Soccer

- 2D sports simulation *(no interactive player)*
- 2 teams ("red" and "blue")
- 5 autonomous agents per team
  - 4 field players
  - 1 goal keeper
- 1 field ("pitch")
- 2 goals
- 1 ball

Simple Soccer Demo

- *Red Team:* BucklandTeam
- *Blue Team:* BurkeTeam
- Keyboard controls
  - P for pause/resume
  - R for reset (new match)
- Frame (update) rate
  - default 60 Hz (FrameRate in Params.ini)
  - can slow down to study behavior more closely
- Match
  - default 5 min (TimeLimit in Params.ini)
  - scoring bonus for using less CPU time (details later)

Why?

- Why should we learn all this complicated, detailed soccer strategy?
  - this is a course about general techniques for game AI, not soccer specifically
- *Answer:*
  - Because there is no other way to appreciate the complexity of building a game AI and the software issues it forces without mastering something complex.
  - Actually, this is only a start and has lots of room for improvement---a platform for your own ideas!

Issues in Simple Soccer

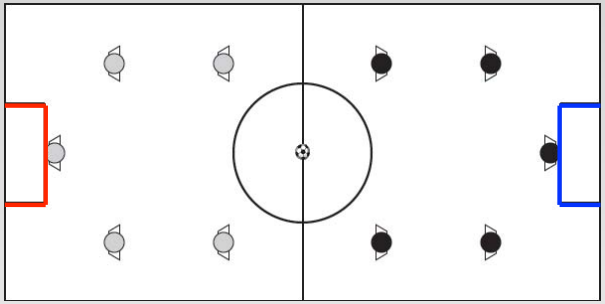
- Geometry and Physics
  - steering
  - navigation
- Tiered AI
  - overall team state machine
  - each player has state machine
  - each player has (changing) role in team
    - e.g., pass receiver
  - messaging between players
    - e.g., "pass me the ball"
- *Soccer-specific strategy and design*

Avoiding Perfection

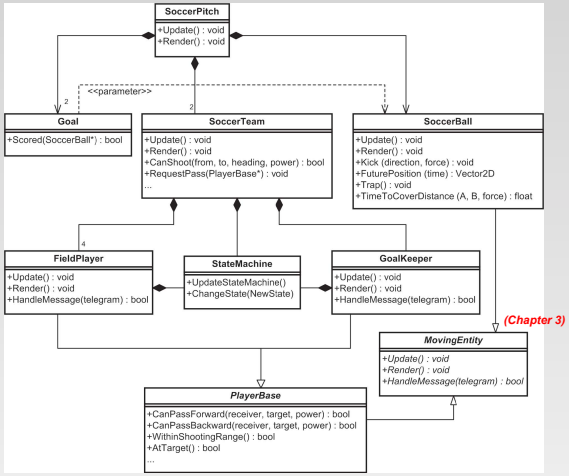
- Like many other genres (e.g., FPS), AI opponents in sports simulations must be *beatable*
  - AI's may have inherently weak strategies (e.g,. no defensive plays in Simple Soccer)
  - explicit fudge factors (e.g., n% of shots go wild)
- Inaccurate (approximate) physics modeling
  - saves compute time, but causes AI's to make mistakes
  - e.g., circles instead of ellipses to calculate interception in Simple Soccer

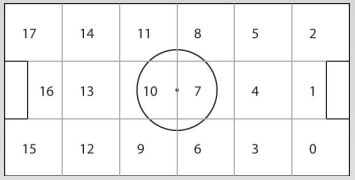
"Stats"-Driven Play

- not illustrated in Simple Soccer
- individual AI performance governed by "stats" (e.g., speed, shooting accuracy)
- interactions between AI's calculated based on stat comparisons and random factors
- typical in reality-based sports games (NBA, etc.)



- Soccer Rule Simplifications
  - ball cannot go over heads of players
  - ball rebounds off walls
  - no corners or throw-ins
  - no off-side rules





- As aid to implementing strategies, pitch divided into 18 regions (numbered 0-17 as above)
- Each player has a "home region"
  - starting point for match
  - may change during play

Soccer Ball Physics

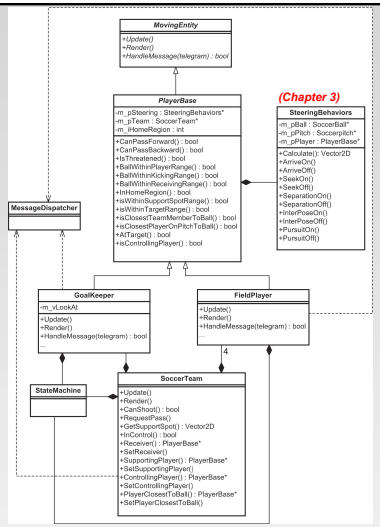
- Three elementary kinematic equations
  - $v = u + at$
  - $d = ut + ½ at^2$
  - $v^2 = u^2 – 2ad$
- Dynamics: F = ma
- Acceleration (a) is Friction in Params.ini
- Soccer ball only checks for collision with pitch boundaries
  - angle of incidence equals angle of reflection
  - ball moves freely through players “feet”

Kicking a Soccer Ball

- In reality:
  - player swings foot toward moving ball
  - force on ball at moment of collision with foot changes velocity of ball
- Approximation in game:
  - pretend ball stopped at moment of kick
  - player gives ball fixed initial velocity
  - easier to calculate
  - looks ok

Soccer Ball Simulation

- Physics simulation or “game” simulation?
- *Answer:* A balance between them
  - enough (approximate) physics to look ok
  - plus other (completely unrealistic) information to make it easier to implement game, e.g.,
    - m_pOwner : a field of ball that points to player that currently “owns” the ball

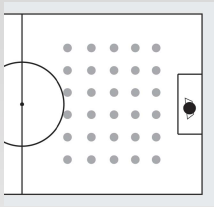


Player Roles in Soccer Team Class

- Closest Player to the Ball
  - updated every tick
  - never null
- Receiving Player
  - waiting to receive kicked ball
  - may be null
- Controlling Player
  - more contextual: passer, receiver, attacker
  - may be null
- Supporting Player
  - works with controlling player
  - always defined when controlling player defined

May need to extend these to improve team strategy!

Scoring Support (Sweet) Spots



SupportSpotCalculator instance for each team

- possible destinations for supporting player in opposing half-pitch (default 13x6)
- each *dynamically* rated for (weights in Params.ini)
  - safe passing (Spot_PassSafeScore)
  - goal scoring potential (Spot_CanScoreFromPositionScore)
  - distance from controlling player (Spot_DistFromControllingPlayerScore)

Code Walk

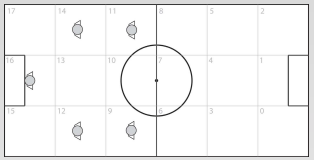
Non-agent entities:

- Soccer pitch
- Goal
- Soccer ball
- Support spot calculator
- Main loop

Team States (Upper Tier AI)

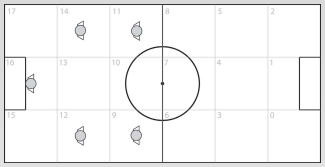
[Demo]

TeamStates::PrepareForKickoff



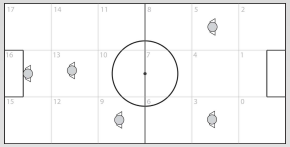
- entered
  - start of match
  - after goal scored
- sends “GoHome” message to all players
- waits until all players are home
- transitions to Defending state

TeamStates::Defending



- change home regions to blue (defending) set
- steers all field players to homes
- if team gets control, transition to Attacking

TeamStates::Attacking



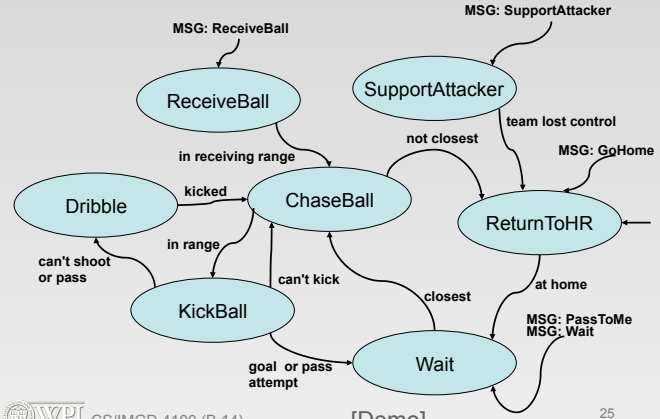
- change home regions to red (attacking) set
- choose supporting player / spot
- if team loses control, transition to Defending

[Code Walk]

FieldPlayerStates::GlobalPlayerState

- handles messages between players
  - Msg_SupportAttacker
  - Msg_ReceiveBall
  - Msg_GoHome
  - Msg_Wait (not used)
- and from team to players
  - Msg_GoHome
  - Msg_PassToMe
- no messages from players to team in this implementation (could add!)

Field Player States



[Demo]

FieldPlayerStates::ChaseBall

- turn on “seek” steering to ball’s current position
- if in kicking range, transition to KickBall
- if no longer closest player, ReturnToHomeRegion
- turn off “seek” when exiting

FieldPlayerStates::Wait

- hold position at current steering target
  - turn on “arrive” steering to return if jostled by another player (collision avoidance)
- if upfield of teammate in control, send Msg_PassToMe to controlling player
- if closest to ball and no current receiver (and goalie does not have ball), transition to ChaseBall

FieldPlayerStates::ReceiveBall

- entered in response to Msg_ReceiveBall
  - telegram contains target location of ball
  - at most one player on team in this state
- choose between “arrive” vs. “pursuit” steering towards ball
  - always use “arrive” if close to goal or threatened
  - otherwise, random variation
- if close enough to ball or team loses control, transition to ChaseBall

FieldPlayerStates::KickBall

- if max kicks/sec exceeded or goalie has ball, transition to ChaseBall
- if CanShoot (see later), Ball()->Kick()
  - random noise, “pot shots”
  - transition to Wait
  - assign supporting player and send Msg_SupportAttacker
- else if threatened and CanPass (see later)
  - assign receiver and send Msg_ReceiveBall
- otherwise, transition to Dribble
  - assign supporting player and send Msg_SupportAttacker

FieldPlayerStates::Dribble

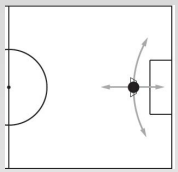
- turn upfield if necessary (maintaining control of ball)
- repeat
  - kick ball short distance
  - transition to ChaseBall
  - which will transition to KickBall
  - which will transition to Dribble

FieldPlayerStates::SupportAttacker

- steer (“arrive on”) to selected support spot
  - support spot re-evaluated every update
- if CanShoot and not threatened, then send Msg_PassToMe to controlling player (attacker)
- if cannot request pass, the remain at support spot and “track” (face) ball
- if team loses control, transition to ReturnToHomeRegion

[Code Walk]

Goal Keeper

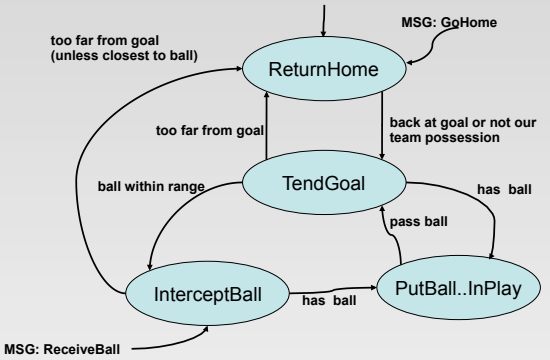


- always faces ball
  - steering behaviors use velocity-aligned heading
  - special vector m_vLookAt

GoalKeeperStates::GlobalKeeperState

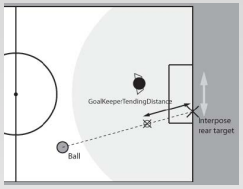
- handles two messages
  - Msg_GoHome
  - Msg_ReceiveBall

Goal Keeper States



[Demo]

GoalKeeperStates::TendGoal



- move laterally, using “interpose” steering to keep body between ball and rear of goal
- if ball comes within control range, transition to PutBallBackInPlay
- if ball comes within intercept range, transition to InterceptBall

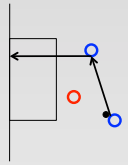
GoalKeeperStates::PutBallBackInPlay

- send Msg_ReturnHome to all field players (including opponents!)
- pass to teammate
- transition to TendGoal

GoalKeeperStates::InterceptBall

- steer towards ball using “pursuit”
- if close enough to trap ball transition to PutBallBackInPlay
- if move too far from goal
  - unless goalie is closest player to ball
  - transition to ReturnHome

Typical Goal Scored on Keeper

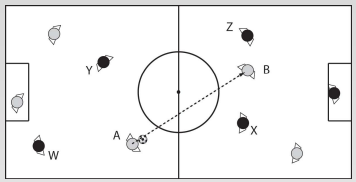


[Code Walk]

Key AI Methods in AbstSoccerTeam

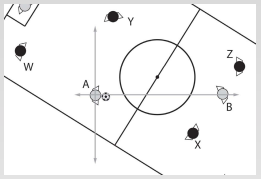
- isPassSafeFromAllOpponents
- CanShoot
- FindPass
- GetBestPasstoReceiver

isPassSafeFromAllOpponents



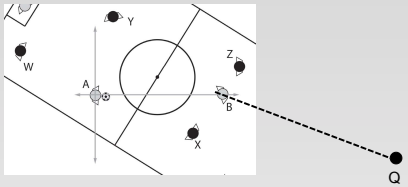
- direct pass
  - assume kicked ball speed > max player speed
  - then any player “behind” kicker is safe
  - how to calculate “behind” ?

isPassSafeFromAllOpponents (cont'd)



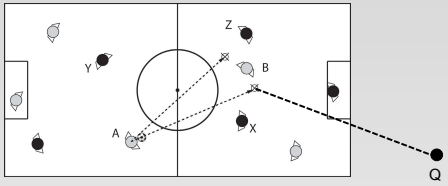
- transform to local coordinates of kicker
- all opponents (e.g., W) with negative x coordinate are "behind" kick (i.e., safe)

isPassSafeFromAllOpponents (cont'd)



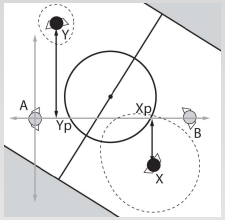
- how about opponents beyond receiver (x coordinate > B), e.g., Q ?
- if direct pass, then ignore Q
  - why?
  - is that reliable?

isPassSafeFromAllOpponents (cont'd)



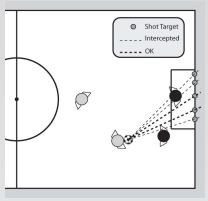
- how about "side passes" ?
- for each side target, consider opponents with x coordinate > target
- if time to receiver (BQ) is greater than pass time (AB), then safe

isPassSafeFromAllOpponents (cont'd)



- how to eliminate remaining opponents?
- compute closest (perpendicular) intercept point (e.g., Xp, Yp)
- compare time for ball vs. opponent to reach intercept point
  - adjustment for ball size and capture distance
  - ignoring time for opponent to rotate

CanShoot

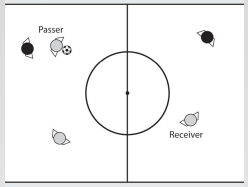


- choose random points along back of goal
- check that not too far (force vs. friction)
- call isPassSafeFromAllOpponents

FindPass

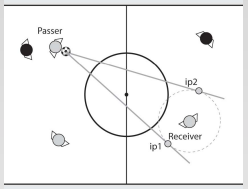
- call GetBestPassToReceiver on each teammate beyond MinPassingDistance
- choose teammate who can safely receive pass that is furthest upfield

GetBestPassToReceiver



- eliminate if receiver too far (force vs. friction)
  - doesn't consider receiver running toward passer
- consider "side passes"

GetBestPassToReceiver (cont'd)



- compute range (dotted circle) of receiver within time duration of pass
  - using time duration to current receiver position
  - reduce range to 30% to allow safety margin (turning, etc.)
- side pass targets are ip1 and ip2
  - check that inside pitch
  - call isPassSafeFromAllOpponents

Code Walk

- isPassSafeFromAllOpponents
- CanShoot
- FindPass
- GetBestPassToReceiver

Params.ini

```
...
// weights used to calculate the support spots
Spot_PassSafeScore                  2.0
Spot_CanScoreFromPositionScore      1.0
Spot_DistFromControllingPlayerScore 2.0
...
```

- you might think that the name on each line identifies the variable that is set
  WRONG
- you might think that the variables can be listed in any order
  WRONG
- ParamLoader.h

Parameter File Loading

- We'll see a much better version of this using Lua in Raven code
  - any order
  - add variables
  - use expressions as values

"Strategic" Parameters

```
// scoring values for support spots
Spot_CanPassScore                   2.0
Spot_CanScoreFromPositionScore      1.0
Spot_DistFromControllingPlayerScore 2.0

// when an opponent comes within this range the player will attempt to
// pass (the higher the value, the more often players tend to pass)
PlayerComfortZone           60.0

// minimum distance a receiving player must be from the passing player
MinPassDistance             120.0
```

"Strategic" Parameters (cont'd)

```
// minimum distance a player must be from the goalkeeper before it will
// pass the ball
GoalkeeperMinPassDistance      50.0

// the distance the keeper puts between the back of the net
// and the ball when using the interpose steering behavior
GoalKeeperTendingDistance      20.0

// when the ball becomes within this distance of the goalkeeper he
// changes state to intercept the ball
GoalKeeperInterceptRange           100.0

// how close the ball must be to a receiver before he starts chasing it
BallWithinReceivingRange       10.0
```


Making Buckland's Code "Multi-User"

- To support tournament play
- Factory pattern for teams
- Unsolved problems:
  - reusing states
  - changing parameters

Factory Pattern

- ***Goal:*** decide at run-time (e.g., by loading info from Params.ini) which team class to make an instance of
  - avoid directly calling "new" with class name in game initialization code
- ***Solution:***
  - define an abstract class (AbstSoccerTeam)
  - with a "factory method" (makeTeam)
  - use inheritance/polymorphism

Factory Pattern

[singleton registry] TeamMaker->newTeam("BurkeTeam")

[singleton factory] BurkeSoccerTeamMaker->makeTeam(...)

[subclass AbstSoccerTeam] **new** BurkeSoccerTeam(...)

What's Not Solved

- All the states need to be copied
  - why?
- Changed values in Params.ini need to be replaced at point of reference
  - why?

G.J. Sussman: "The flexibility of a unit of code is directly proportional to the number of levels of *indirection* it uses."

Coming up...

- *Fri-Sun:* Study Buckland Team Behavior
- *Sunday:* My Team Homework Due
- *Mon:* Brainstorming in Class
- *Weds:* Team Design Homework Due
- *Weds 10pm:* Tournament Team Homework Due