



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]

IMGD 4100 (B 11) 1

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:** Discussion of Team Improvements
- **Weds midnite:** “Team Design” homework due [3 pt]
- **Weds midnite:** “Tournament Team” due [10 pt]
 - full credit for beating Buckland's team
- **Thu Nov. 19:** Soccer tournament (IMGD Lab)
 - bonus points for winning elimination matches



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Week	Day	Book	Lecture	Homework
1	Tue, Oct 25		Intro/Overview/Admin	
	Wed, Oct 26			1 - Hello West World [3%]
	Thu, Oct 27	Chapter 2	State Machines	
	Fri, Oct 28	Chapter 2	Event Messages	
	Sun, Oct 30			2 - Bar Fly [5%]
2	Mon, Oct 31	Chapter 4	Simple Soccer Anatomy	
	Tue, Nov 1	Chapter 4	Simple Soccer Anatomy	
	Wed, Nov 2			3 - Tank States [5%]
	Thu, Nov 3	Chapter 4	Simple Soccer Anatomy	
	Fri, Nov 4		Futures: AIIDE Conference Highlights	
	Sun, Nov 6			4 - My Team [3%]
3	Mon, Nov 7		Brainstorming: Simple Soccer Strategy	
	Tue, Nov 8	Chapter 6	LUA Scripting	
	Wed, Nov 9			5 - Team Design [3%]
	Thu, Nov 10	Chapter 6	LUA Scripting	
	Fri, Nov 11		Futures: Neuroevolution of Combat Bots	
	Sun, Nov 13			6 - Scripting [5%]
4	Mon, Nov 14	Chapter 7	Raven Anatomy	
	Tue, Nov 15	Chapter 7	Raven Anatomy	
	Wed, Nov 16			7 - Tournament Team [10%]
	Thu, Nov 17		Soccer Tournament (IMGD Lab)	
	Fri, Nov 18		Futures: TBD	
	Sun, Nov 20			8 - My Bot [3%]

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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



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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

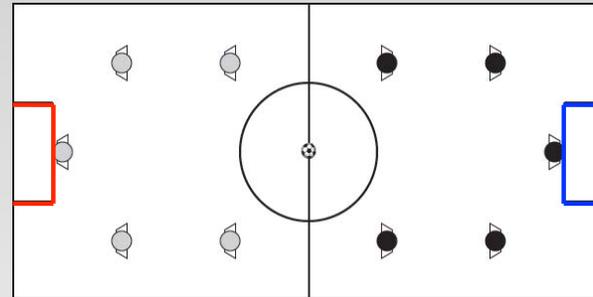
- Geometry and Physics
 - steering
 - navigation
- Tiered AI
 - overall team state machine
 - each player has state machine
 - each player has (changing) role in team
 - e.g., pass receiver
 - messaging between players
 - e.g., "pass me the ball"
- **Soccer-specific strategy and design**

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

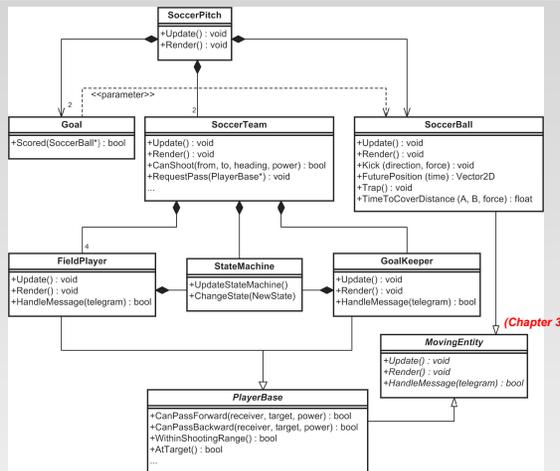
“Stats”-driven Play

- 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.)
- not illustrated in Simple Soccer



Soccer Rule Simplifications

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



17	14	11	8	5	2
16	13	10	7	4	1
15	12	9	6	3	0

- 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

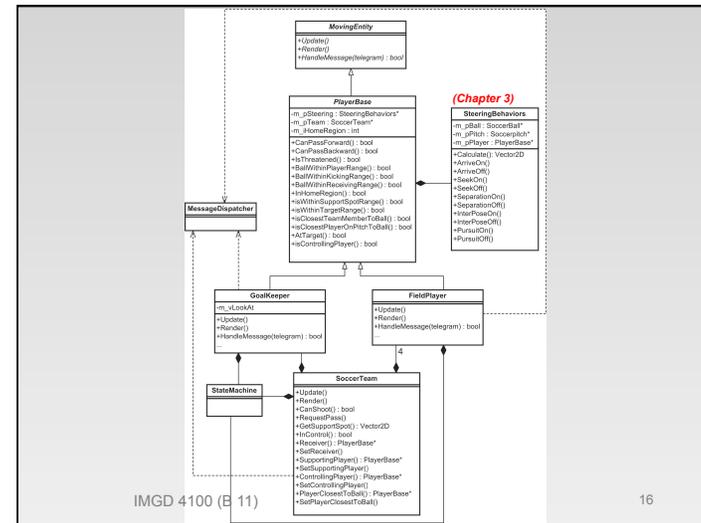
- Three elementary kinematic equations
 - $v = u + at$
 - $d = ut + \frac{1}{2} at^2$
 - $v^2 = u^2 - 2ad$
- Dynamics: $F = ma$
- Acceleration (a) is Friction in Params.ini
- Soccer ball only checks for collision with pitch boundaries
 - angle of incidence equals angle of reflection
 - ball moves freely 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

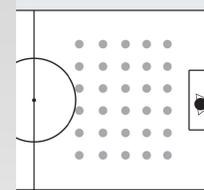


Player Roles in Soccer Team Class

- Receiving Player
 - waiting to receive kicked ball
 - may be null
- Closest Player to the Ball
 - updated every tick
 - never 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:

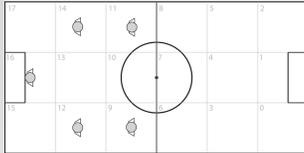
- Soccer pitch
- Goal
- Soccer ball
- Support spot calculator
- Main loop

Team States (Upper Tier AI)



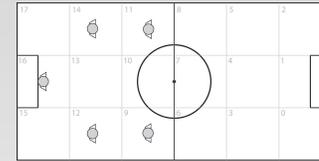
[Demo]

TeamStates::PrepareForKickoff



- entered
 - start of match
 - after goal scored
- sends all players to (defending) home regions
- “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

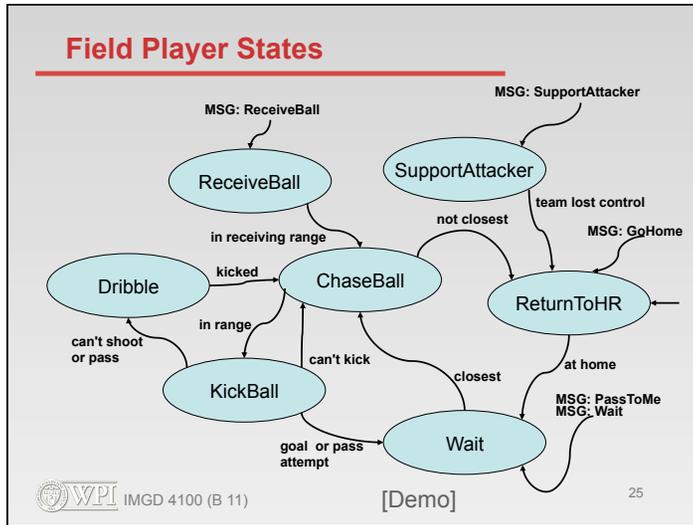


- change home regions to red (attacking) set
- choose supporting player / spot
- if team loses control, transition to Defending

[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!)



- ### 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

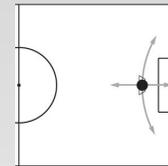
- turn upfield if necessary (maintaining control of ball)
- repeat
 - kick ball short distance
 - transition to ChaseBall
 - which will transition to KickBall
 - which will transition to Dribble

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

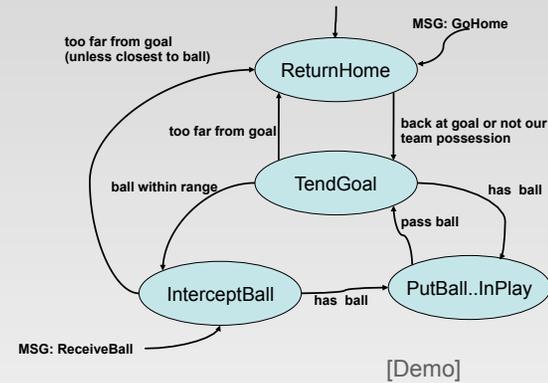


- always faces ball
 - steering behaviors use velocity-aligned heading
 - special vector m_vLookAt

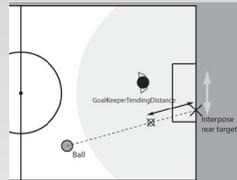
GoalKeeperStates::GlobalKeeperState

- handles two messages
 - Msg_GoHome
 - Msg_ReceiveBall

Goal Keeper States



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

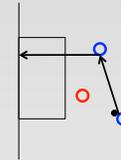
GoalKeeperStates::PutBallBackInPlay

- 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

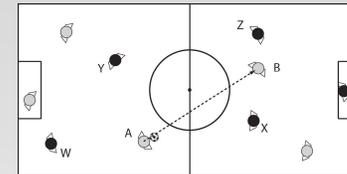


[Code Walk]

Key AI Methods in AbstSoccerTeam

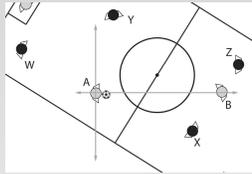
- isPassSafeFromAllOpponents
- CanShoot
- FindPass
- GetBestPasstoReceiver

isPassSafeFromAllOpponents



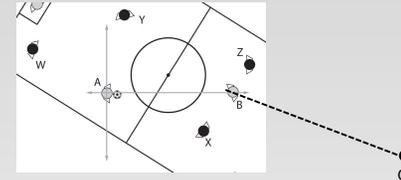
- direct pass
 - assume kicked ball speed > max player speed
 - then any player “behind” kicker is safe
 - how to calculate “behind” ?

isPassSafeFromAllOpponents (cont'd)



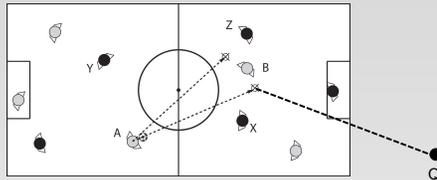
- transform to local coordinates of kicker
- all opponents (e.g., W) with negative x coordinate are “behind” kick (i.e., safe)

isPassSafeFromAllOpponents (cont'd)



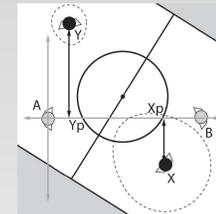
- how about opponents beyond receiver (x coordinate > B), e.g., Q ?
- if direct pass, then ignore Q
 - why?
 - is that reliable?

isPassSafeFromAllOpponents (cont'd)



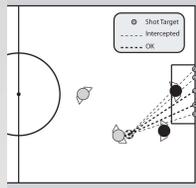
- how about “side passes” ?
- for each side target, consider opponents with x coordinate > target
- if time to receiver (BQ) is greater than pass time (AB), then safe

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

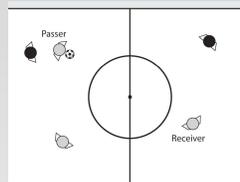


- choose random points along back of goal
- check that not too far (force vs. friction)
- call isPassSafeFromAllOpponents

FindPass

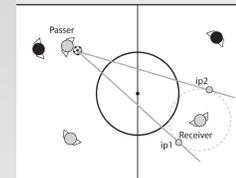
- call **GetBestPassToReceiver** on each teammate beyond MinPassingDistance
- choose teammate who can safely receive pass that is furthest upfield

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



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
- *Mon:* Brainstorming in Class
- *Weds:* Team Design Homework
- *Weds:* Tournament Team Homework