



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]

CS/IMGD 4100 (B 16)

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Plan for next three weeks (re Soccer only)

Read Chapter 3 on Steering!

- **Mon/Tue/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
- **Wed midnite:** “Team Design” homework due [3 pt]
- **Wed (two weeks later):** “Tournament Team” due [10 pt]
 - requires adding *substantial* new strategy
- **Fri, Nov 18:** Soccer tournament (HL 230)
 - final grade bonus points for winner and runner-up



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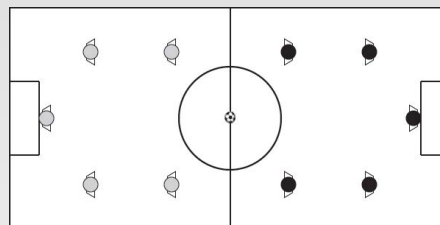
2

The Road to Tournament...

Day	Book	Lecture (with links to notes)	Homework (with links)
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%]
⇒ 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		Research: AIIDE Conference	
Sun, Nov 6			4 - My Team [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		Procedural Content Generation	
Sun, Nov 13			6 - Scripting [5%]
Mon, Nov 14		Procedural Content Generation	
Tue, Nov 15	Chapter 7	Raven Anatomy	
Wed, Nov 16			7 - Tournament Team [10%]
⇒ Thu, Nov 17	Chapter 7	Raven Anatomy	
Fri, Nov 18		Soccer Tournament (HL 230 !)	

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?
 - after all, this is a course about general techniques for game AI, not soccer specifically...
- *Answer:*
 1. Because there is no other way to appreciate the real issues in building a game AI without mastering something reasonably complicated.
 2. Actually, this is only a start and has lots of room for improvement---a platform for your own ideas!

Design Issues in Simple Soccer

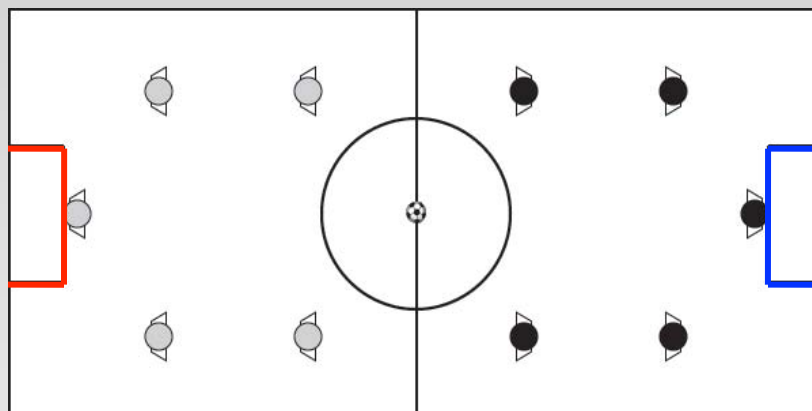
- Geometry and Physics
 - steering
 - navigation
- Tiered AI
 - overall team state machine
 - each player has state machine
 - each player has (changing) role in team
 - e.g., pass receiver
 - messaging between players
 - e.g., “pass me the ball”
- *Soccer-specific strategy and design*

Avoiding Perfection

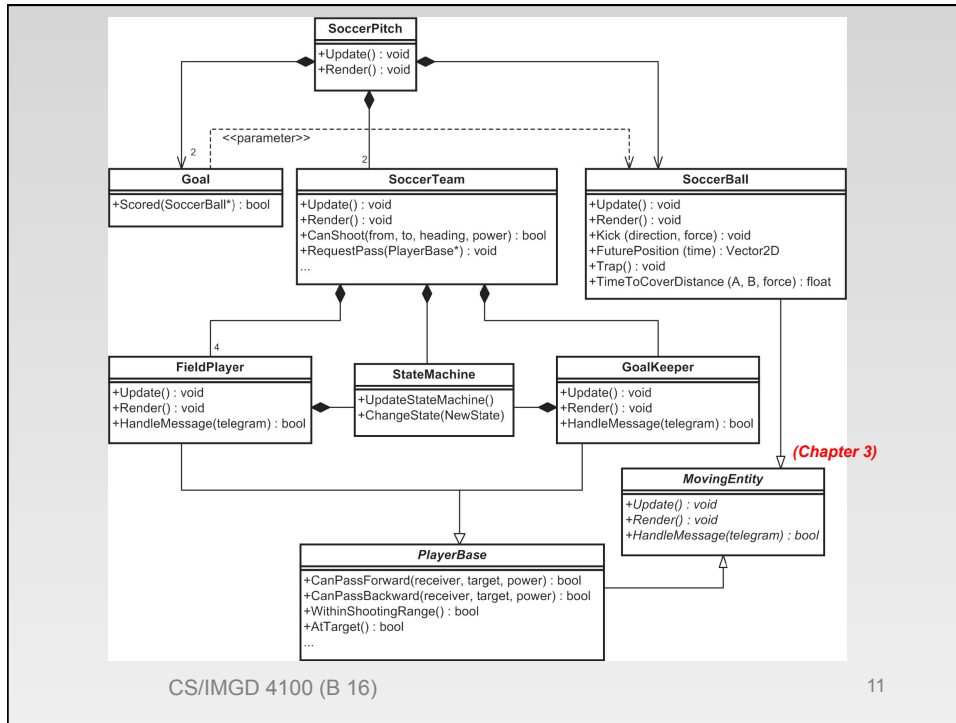
- Like many other genres (e.g., FPS), AI opponents in sports simulations must be *beatable*
 - AI's may have inherently weak strategies (e.g., no defensive plays in Simple Soccer)
 - explicit fudge factors (e.g., n% of shots go wild)
- Inaccurate (approximate) physics modeling
 - saves compute time,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

How about “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
 - ball does not collide with players’ feet
 - no corners or throw-ins
 - no off-side rules



(Home) Regions

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

Simple Soccer Physics

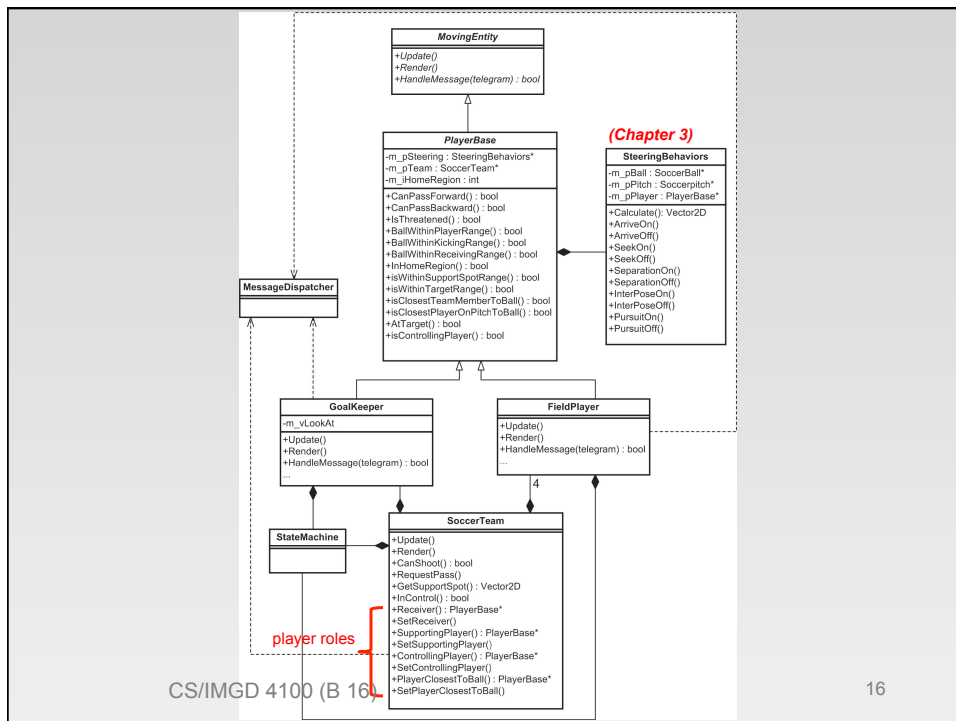
- **Physics** simulation or “**game**” simulation?
- *Answer:* A **balance** between them
 - enough (approximate) physics to look ok
 - plus other (completely unrealistic) information to make it easier to implement game, e.g.,
 - m_pOwner : a field of ball that points to player that currently “owns”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

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”

Reality vs. Approximation

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



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

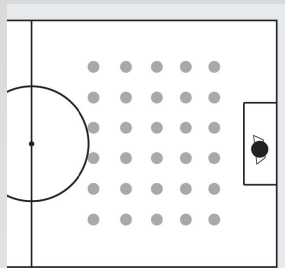
May need to extend these to improve team strategy!



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Scoring Support (Sweet) Spots



SupportSpotCalculator
instance for each team

“Heat Map”

- 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`)



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[Demo]

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Code Walk

Non-agent entities:

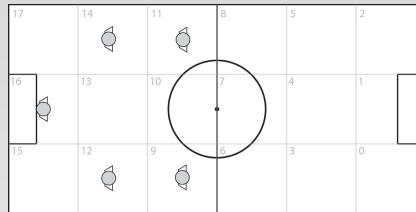
- Soccer pitch
- Goal
- Soccer ball
- Support spot calculator
- Main loop

Team States (Upper Tier AI)



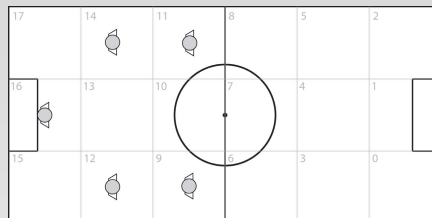
[Demo]

TeamStates::PrepareForKickoff



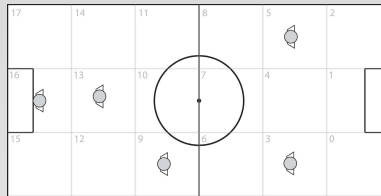
- entered
 - start of match
 - after goal scored
- sends “GoHome” message to all players
- waits until all players are home
- transitions to Defending state

TeamStates::Defending



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

TeamStates::Attacking

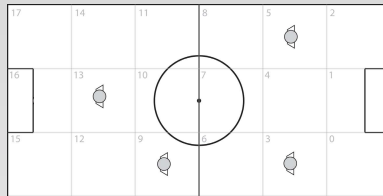


- change home regions to attacking set
- choose supporting player / spot
- if team loses control, transition to Defending

FieldPlayerStates::GlobalPlayerState

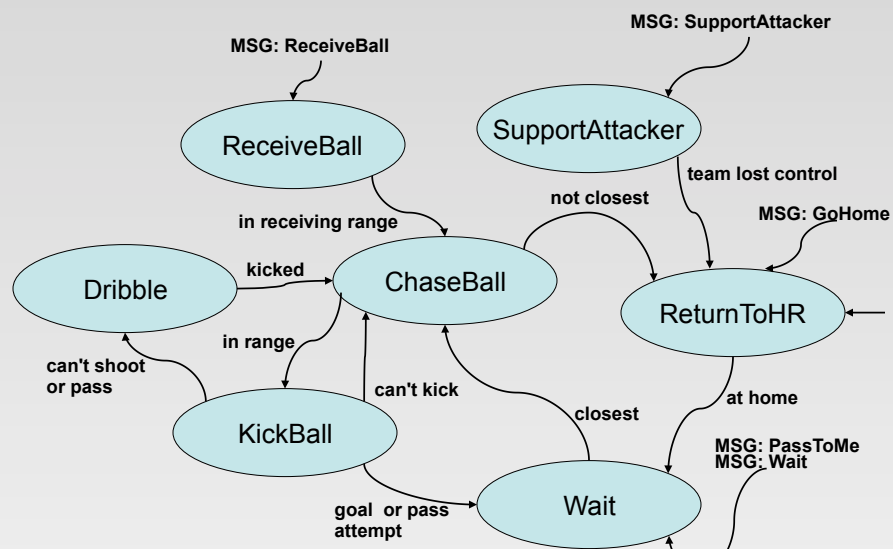
- handles messages between players
 - Msg_SupportAttacker
 - Msg_ReceiveBall
 - Msg_GoHome
 - Msg_Wait (not used)
- and from team to players
 - Msg_GoHome
 - Msg_PassToMe
- no messages from players to team in this implementation (could add!)

Field Players (4)



- 2 attackers
 - 2 defenders
- (field in PlayerBase)

Field Player States



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`

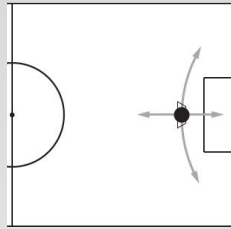
FieldPlayerStates::Dribble

- 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

Goal Keeper

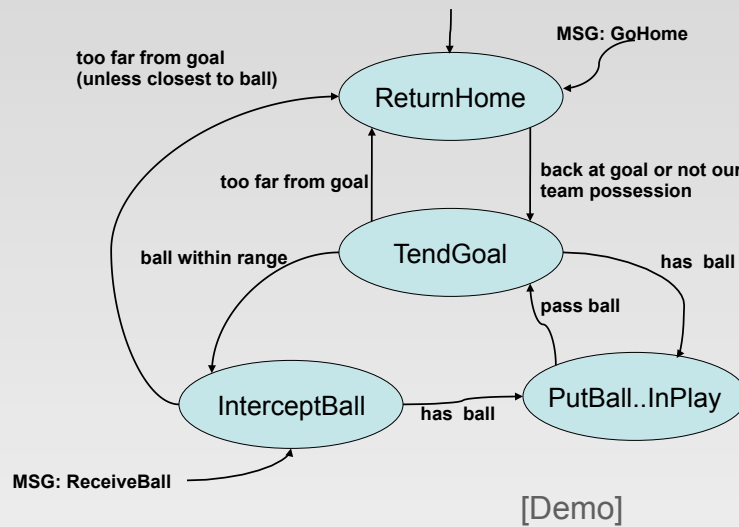


- always faces ball
 - steering behaviors use velocity-aligned heading
 - special vector `m_vLookAt`

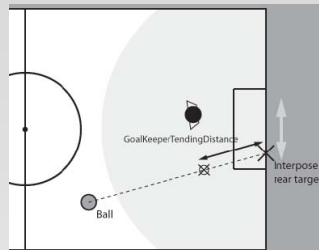
GoalKeeperStates::GlobalKeeperState

- 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

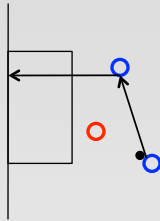
GoalKeeperStates::PutBallBackInPlay

- 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

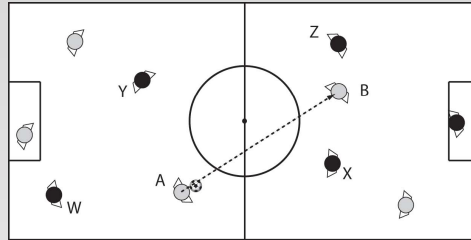
Typical Goal Scored on Keeper



Key AI Methods in AbstSoccerTeam

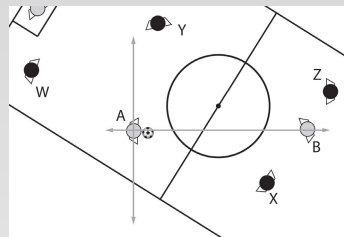
- isPassSafeFromAllOpponents
- CanShoot
- GetBestPasstoReceiver
- FindPass

isPassSafeFromAllOpponents



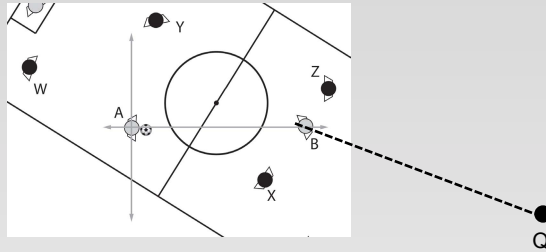
- direct pass
 - assume kicked ball speed $>$ max player speed
 - then any player “behind” kicker is safe
 - how to calculate “behind” ?

isPassSafeFromAllOpponents (cont'd)



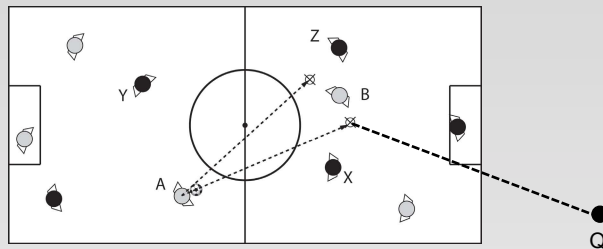
- transform to local coordinates of kicker
- all opponents (e.g., W) with negative x coordinate are “behind” kick (i.e., safe)

isPassSafeFromAllOpponents (cont'd)



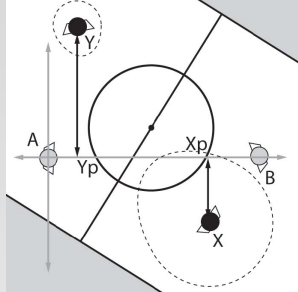
- how about opponents beyond receiver (x coordinate $> B$), e.g., Q ?
- if time to receiver (BQ) is greater than pass time (AB), then safe

isPassSafeFromAllOpponents (cont'd)



- how about “side passes” ?
- for each side target, similarly consider times for opponents with x coordinate $>$ target

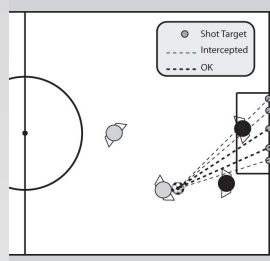
isPassSafeFromAllOpponents (cont'd)



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

[\[Code Walk\]](#)

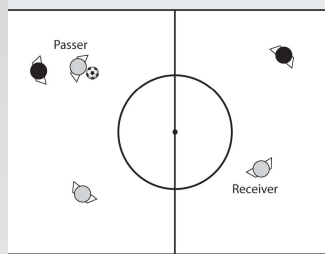
CanShoot



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

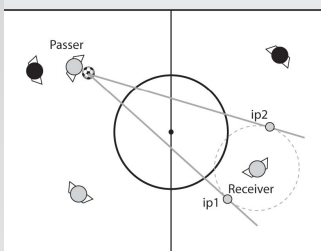
[\[Code Walk\]](#)

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**

[\[Code Walk\]](#)

FindPass

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

[Code Walk]

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

Field Player “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

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

Goalie “Strategic” Parameters

```
// 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
```

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
- Params.ini

```
RedTeam  SmithTeam
BlueTeam JonesTeam
```

- **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 team and player states need to be copied
 - why?
 - you are doing this in HW 4 – My Team
- Values you desire to change in Params.ini need to be replaced each place they are referenced in your team code!
 - why?
 - replace `Prm.MinPassDistance` by `25`

Coming up...

- *[Fri:* Research Snapshot: AIIDE 2014]
- *Sun:* “My Team” Homework Due
- *Mon:* Brainstorming in Class
- *Wed:* “Team Design” Homework Due
- *Wed after:* “Tournament Team” HW Due