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Ultimate Frisbee Coaching Simulator

Ultimate frisbee is a sport where two teams of seven players each try to score goals by passing a frisbee to advance up the field. Players think strategically to complete passes that bring their team closer to the end zone and to stop the other team from scoring. I have created diagrams that show the flow of the game and show the actions a player can take and the constraints on the player. These diagrams should help to create intelligent players for an ultimate frisbee coaching simulator.

In ultimate frisbee, the pull starts play when the pulling team throws the frisbee to the receiving team at the beginning of each half and after each goal. After the thrower gains possession of the disc, the thrower establishes a pivot and cannot change the pivot until the disc is thrown. The defender who guards the thrower is called the marker. The thrower must throw the disc before the marker's stall count reaches ten or else the offense loses possession of the disc. If a receiver does not catch a pass inbounds before the disc hits the ground, or if the pass is intercepted, the offense again would be committing a turnover. Only one marker can guard the thrower. Other defensive players cannot establish a position within three meters of the thrower's pivot unless the defender is guarding another offensive player in the area. In general, fouls and violations cause play to stop. Play continues after a check. A foul occurs when there is physical contact between players on different teams and the outcome of the play is affected. A team scores

a goal when a player catches a pass in the end zone of attack. After scoring, the teams switch the direction of their attack. In a standard game, the first team to score at least 15 goals and to lead by at least two goals is the winner (“UPA Rules of Ultimate”).

The game of ultimate frisbee must have a certain order to it, regardless of how intelligent the players are. The rules dictate how the game should proceed for any action the player can take. In order to help make explicit the order to the game, I created a diagram of the states in the game and the transitions between them. It is shown in Figure 1.

The transitions are indicated by arrows in the state diagram. The transitions happen nearly instantaneously, so the game is always described as being in one of the states. Each state can transition to itself, so if none of the transitions from a state happen, the game would simply remain in the same state. In the diagram, the states have been arranged into groups as well. Related states have been arranged into groups to help understand the flow of the game.

The groups that the states in the state diagram are arranged in are extended break, pull, pass, disc on ground, dead disc, thrower moving to spot, thrower moving to spot stalling, drop disc, and getting alternative game disc. The following is a description of the states in each group:

extended break:

start game: This is the state at the start of the game. One team chooses either to receive or pull or to initially defend a certain end zone. The other team then makes a choice about the remaining option.

halftime: Halftime occurs when one team’s score becomes greater than or equal to half of the minimum score needed to win. The choices made at the beginning of the game are reversed. Halftime is ten minutes long.

end game: After a team scores the winning goal, the game will be in the end game state.

pull:

before pull not ready: The game is in this state when the disc is going to be pulled but before either team has signaled readiness.

before pull pulling ready: The game is in this state when the disc is going to be pulled, the pulling team has signaled readiness, and the receiving team has not signaled readiness. Players on the pulling team can move anywhere within their own end zone, but cannot cross the goal line until the disc has been thrown.

before pull receiving ready: The game is in this state when the disc is going to be pulled, the receiving team has signaled readiness, and the pulling team has not signaled readiness. Players on the receiving team have to stand with one foot on the goal line they are defending without changing position relative to each other.

before pull ready: The game is in this state when the disc is going to be pulled and both teams have signaled readiness.

pull in flight: This state is after the pull has been thrown but before it has touched the ground or a player.

pull hit ground out of bounds: The game is in this state if the receiving team is trying to retrieve a pull that initially hit the ground out of bounds, but a player on the receiving team has not signaled for a brick.

signaled brick: This state is when the receiving team has signaled for a brick but has not entered a delay of game situation nor had a player gain possession of the disc.

pull hit ground inbounds: The pull has hit the ground inbounds but has not gone out of bounds or been touched by a member of the receiving team.

pull bounces out of bounds untouched by receiver: The pull hit the ground inbounds and rolled out of bounds untouched by the receiving team and without entering a delay of game situation.

touched by receiver before pull hit ground: The game is in this state when the pull is touched by the receiver before hitting the ground and before being caught.

pull touched by receiver after hitting ground: The game is in this state if the pull is touched by a receiver after hitting the ground inbounds and before going out of bounds.

pull bounces out of bounds touched by receiver: The game is in this state if the receiving team is trying to retrieve the disc without causing a delay of game after the pull hits the ground inbounds, is touched by a receiver, and goes out of bounds.

pass:

thrower has disc in play: The thrower has the disc in play and is not in a throwing motion.

thrower in throwing motion: The thrower is in a throwing motion. Pivoting and winding up are not part of the throwing motion.

pass in air: This state occurs from when the thrower releases the disc to when the disc is caught or hits the ground.

disc on ground:

disc on ground in playing field proper after being in play, disc on ground out of bounds after being in play, disc on ground in thrower end zone of attack after being in play, disc on ground in thrower end zone of defense after being in play: The game is in one of these states when the disc is on the ground following a turnover after being in play. The playing field proper is the playing field not including the end zones. The thrower referred to in the state names is the thrower who threw the disc that resulted in a turnover. The disc locations referred to in the state names determine how the thrower acts after gaining possession.

dead disc:

time out: The game is in this state when a time out occurs. The time out can be a team time out, an injury time out, or an equipment time out. A team time out is 70 seconds long.

before ready: The game is in this state when the disc is to be self-checked and the team has not signaled readiness yet. The defense needs to signal readiness for a offensive self-check and the offense needs to signal readiness for a defensive self-check.

to be checked: The game is in this state when the disc has not been checked yet and no team needs to signal readiness.

thrower moving to spot:

thrower moving to brick mark closest to end zone of defense, thrower moving to spot on long axis nearest to last inbound disc location, thrower moving to spot on playing field proper nearest to last inbound disc location, thrower moving to spot on playing field nearest to last inbound disc location, thrower moving to spot on playing field nearest to spot where caught, thrower moving to closest spot on goal line, thrower moving to spot on playing field proper nearest to most recent of 4 events, thrower moving to spot on playing field proper nearest disc location: The thrower is moving to a certain spot on the field without being in a delay of game situation.

thrower moving to spot stalling:

thrower moving to brick mark closest to end zone of defense stalling, thrower moving to spot on long axis nearest to last inbound disc location stalling, thrower moving to spot on playing field proper nearest to last inbound disc location stalling, thrower moving to spot on playing field nearest to last inbound disc location stalling, thrower moving to spot on playing field nearest to spot where caught stalling, thrower moving to closest spot on goal line stalling, thrower moving to spot on playing field proper nearest to most recent of 4 events stalling, thrower moving to spot on

playing field proper nearest disc location stalling: The thrower is moving to a certain spot on the field or a player is moving to pick up the disc and to move to a spot while being in a delay of game situation.

drop disc:

drop disc in playing field proper, drop disc out of bounds, drop disc in thrower end zone of attack, drop disc in thrower end zone of defense: The game is in one of these states from when the disc of a thrower moving to a spot hits the ground to when a player on the other team gains possession of the disc. The location, referred to in the state name, is determined by where the disc is dropped.

getting alternative game disc:

getting alternative game disc: An offensive player is moving to obtain an alternative game disc after an out of bounds disc becomes unretrievable within 20 seconds.

Having a state diagram of state in the game helps when trying to dictate the flow of the game. However, the behavior of a player to play in an intelligent manner is still left mostly unconstrained. By only dealing with constraints to control the flow of the game, there is nothing stopping players from doing things like wandering out of bounds or throwing passes to no one towards the end zone the thrower's team is defending. As a result, I created a diagram that details the actions a player can take and the constraints on a player. It is shown in Figure 2.

The diagram is a tree of roles that a player can fill and the actions and constraints associated with those roles. The root of the tree is the player role, which is broken down into the four subroles offense, defense, pulling, and receiving. These roles are broken down into more subroles. The role a player fills at any one time can be thought of as a path through the tree, starting at the root, that does not necessarily reach a leaf where the more specialized roles are.

The path has to at least extend as far as a player's role as specified by the rules, such as a receiver. Additional roles can be added as leaves to the tree, so things like roles from additional offensive and defensive formations can be added.

The actions a player in a role can take and the constraints on that role are divided into three categories. They are things a player can choose to do or not to do, things that are strongly recommended, and things that have to be done. For example, a receiver can choose to make a cut, is strongly recommended to stay/get inbounds, and has to not purposefully control bobbling to self. Some actions and constraints are only of concern at certain points in time. For example, touching the disc to the ground in the thrower role is only of concern when the thrower is putting the disc into play at a location other than where the thrower gained possession.

When the information from the game state diagram is combined with the information from the player diagram, one can begin to expect to simulate a game of ultimate frisbee that looks somewhat realistic. The state diagram can be represented by a matrix with the states representing the rows and columns and an entry in the matrix being true if there is a transition from the state represented in the row to the state represented in the column. For the player diagram, a matrix can also be used. The rows would represent states and the columns would be the actions and constraints. An entry in the matrix would represent the priority of the action or constraint in the state. Another matrix with both the rows and columns representing actions or constraints would have as entries if the row and column actions or constraints could occur at the same time. Higher priority actions and constraints would take precedence over lower priority ones when determining how the player should move and act. Sometimes, an action needs to be considered only part of the time when in a state. When it does not need to be considered, the action would be lower priority than other actions and constraints, even if the action was categorized as a high priority. Actions

and constraints that do not need to be considered at all in a state can be given a special value that indicates that it has no priority.

In order to make players that carry out actions and observe constraints intelligently, the simulator can incorporate the ideas of the subsumption architecture as described by Rodney Brooks (1985). The idea of the subsumption architecture is to break down the goals of the thing that is trying to be made intelligent, in this case the player, into several levels of competence. At the lowest level, level 0, the player exhibits the most basic desired actions. Higher levels add more competence to the player while including as a subset the earlier levels of competence. Higher levels can suppress the actions of lower levels, allowing each level to pursue its own goals. By creating the simulation using the subsumption architecture, a working simulation can be created relatively early in the development process and higher levels of competence can be added without having to change the lower levels which work properly.

In the ultimate frisbee simulator, a player could follow the rules and implement the easy actions and constraints from the player diagram at level 0. For example, the thrower might only make passes that are short, to wide open receivers, or to the dump at level 0. At level 1, the thrower might make longer passes to cutting receivers. At higher levels, the thrower might try more complex throws and would know when it is necessary to make more dangerous throws.

In order to make the simulator believable, the players' movements and awareness levels need to be somewhat realistic. Some of the attributes a player could have are maximum velocity forward, maximum velocity backward, maximum velocity sideways, maximum acceleration forward, maximum acceleration backward, maximum acceleration sideways, height, mass, reaction time, endurance, field awareness, head direction, body direction, maximum angular velocity, and maximum angular acceleration. Field awareness is how well a player is aware of the

locations of the other players and the disc. Players can see what is in front of them and possibly estimate where players close behind them are. The maximum velocities and accelerations in other directions are linear combinations of the forward, backward, and sideways maximum velocities and accelerations. When a player's acceleration is maximum, his velocity should be zero, and when a player's velocity is maximum, his acceleration should be zero. Also, when trying to avoid contact with other players, a player should estimate the path other players will take within the next second. Finally, the thrower should try to make passes to a certain part of the field at a certain height and the receiver will try to move to the spot and catch the pass. The frisbee should follow a simple path and possibly follow more complex paths as the simulator evolves.

The game state diagram and the player diagram provide a good foundation of knowledge from which intelligent players can be built. A good coaching simulator would help beginners gain a decent understanding of ultimate frisbee while advanced players may develop a better understanding of how to react in different situations.

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