Virtual Quidditch:
A Challenge Problem for Automatically Programmed Software Agents

Lee Spector
Cognitive Science
Hampshire College
Amherst, MA 01002
lspector@hampshire.edu

Ryan Moore
Cognitive Science
Hampshire College
Amherst, MA 01002
ryan_moore@hampshire.edu

Alan Robinson
Cognitive Science
Hampshire College
Amherst, MA 01002
Alan@HciDesign.com

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Alan Robinson
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Alan@HciDesign.com

Abstract

This paper describes a new challenge problem for the automatic programming of software agents, a virtual version of the quidditch game invented by J. K. Rowling in her best-selling *Harry Potter* books (Rowling and Grandpre, 1998; Rowling and Whisp, 2001). Good performance in this game requires adaptive control in a complex, heterogeneous, and dynamic 3-dimensional environment. In this short paper we briefly describe virtual quidditch and the challenges that it presents. A quidditch simulator environment is currently being developed; when it is complete it will be made publicly available.

1 VIRTUAL WORLDS FOR AGENT DEVELOPMENT/EVOLUTION

Several technical challenges face the designer of a control system for an agent in a complex, dynamic environment. While the ultimate goal for many researchers is the development of techniques that will enable autonomous agents to perform well in the real (physical) world, the difficulties and expense involved in robotics experimentation has led many researchers to test their ideas first in game-like virtual environments.

Such environments have been host both to hand-coded agents and to agents developed with the aid of automatic programming techniques such as genetic programming (Koza, 1992). In particular, genetic programming and related techniques have been used to develop agents for TileWorld (Iba, 1999), Wumpus World (Spector, 1994), predator/prey and pursuer/evader problems (Deakin and Yates, 1998; Haynes and Sen, 1996; Luke and Spector, 1996), coordinated vehicle movement problems (Qureshi, 1996), artificial ant and food foraging problems (Bennett, 1996; Bongard, 2000), simulated robotic soccer (Andre and Teller, 1999; Luke, 1998; Sałustowicz, Wiering, and Schmidhuber, 1997), high-fidelity flight simulators (Cribbs, 1999), and other dynamic environments.

2 VIRTUAL QUIDDITCH

For our work on control and adaptation in complex, dynamic environments we required a problem environment with additional features that are representative of a wider range of real-world problems. Virtual quidditch was developed to fill this need. In particular, virtual quidditch is:

- *Richly heterogeneous* — Not only are there players with different roles, on two different teams, but the balls themselves are active and to some extent intelligent.
- *Richly 3-dimensional* — Quidditch is a flying game in which it is essential to reason about 3D positions and movement. Most previously studied environments are either 2D or, like soccer, make limited use of the third dimension.
- *Extensible* — The rules are not uniquely determined by the Rowling books and amendments/adjustments can easily be made to increase task difficulty or to broaden task requirements. Indeed, since the mechanics of the game are maintained by magic spells anyway, no conceivable adjustments will seem out of character!
- *Beyond human experience* — While Rowling's books describe elements of Quidditch strategy we have no real evidence about what sorts of strategies will be most effective. This means that agent designers cannot intentionally or unintentionally leverage their own experience with the game in

designing agents. Neither can users of automatic programming technologies build experience-based assumptions into the primitives or parameters of their systems.

- *Like real-time, only faster* — Our quidditch server will *model* some aspects of real-time behavior but in contrast to truly real-time simulators (such as that for Simulation League RoboCup (Corten et al., 1999)) it will be possible to run our simulator significantly faster. This is will allow for rapid assessment of team quality which will facilitate the application of genetic programming and other automatic programming techniques.

3 RULES OF THE GAME

J. K. Rowling's books do not provide full details on the mechanics of the game of Quidditch. Even where they do provide details they are not always completely compatible with the requirements for computer simulation or with the goals of this project. What follows is our attempt to flesh out the rules in a manner that is consistent both with our goals and with the rules that *are* provided by Rowling, although some simplifications, extensions, and adjustments to Rowling's rules have been made in the process.

Further details have yet to be completely specified; for example, we have not yet worked out the simulation details for the way in which players will grip balls or the penalties to be levied for various fouls. These issues will be addressed as we complete our implementation of the quidditch server and will be documented in the accompanying user guide. The rules specified below will suffice to give the reader the basic flavor and rules of the game.

3.1 OVERVIEW

The game of quidditch involves two opposing teams on flying broomsticks trying to score goals. Goals are scored by throwing a large leather ball through one of three round hoops that each team guards at their end of a large oval field. Simultaneously, two large flying iron balls are trying to knock players off of their broomsticks, the prevention of which is attempted by two players on each team using large bats. Finally, a small fourth ball is avoiding capture by a single designated player from each team; the capture of this ball is the equivalent of 15 goals and also marks the end of the game.

3.2 THE FIELD OR "PITCH"

Quidditch is played above a large oval field measuring 500 feet long and 180 feet wide (larger than a football field) with a two foot diameter circle in the middle. Because the game takes place in the air, the pitch should be thought of as an infinitely vertical boundary space rather than a delineated plane. At each end of the field there are three hoops on 50 foot poles. A small space around the three poles is the scoring area. The boundary of the scoring area is an arc with a radius of 20 feet drawn from a center point at the end of the field.

Bleachers are generally floating 50 feet in the air — of course this has no direct impact on virtual quidditch since there is no role for simulated spectators, but a 50-foot-high perspective should be used for visualization. Figure 1 shows one view of the quidditch pitch.

3.3 THE FOUR QUIDDITCH BALLS

Players score goals with the *quaffle*. It is red, twelve inches in diameter, and made of seamless leather. It is enspelled in such a way that it can be held with only one hand. Although it does not fly per se, it will remain suspended in mid air wherever it is released. Two balls called *bludgers* fly around the field trying to hit players. They are made of iron and are ten inches in diameter. The fourth ball, the *golden snitch*, is about the size of a walnut and has two silver wings attached. It avoids capture by either team with great speed and maneuverability. The snitch can also vanish for long periods of time and reappear at random places and times; for this reason a team cannot concentrate all of its efforts on the snitch but must also work to score goals (and to prevent the opposing team from scoring) when the snitch cannot be found.

3.4 QUIDDITCH PLAYERS

Each team has a *keeper* to protect the goals, three *chasers* for scoring, two *beaters* to hit the bludgers, and one *seeker* to catch the golden snitch.

The keeper guards the three hoops at his or her team's end of the field. The keeper usually stays in the scoring area. Two interesting keeper strategies from the Rowling books are 1) weaving at very high speed around all three hoops, and 2) hanging off the broomstick by an arm and a leg with all other limbs outstretched. Because we do not model player bodies in detail, however, the second of these strategies and others like it are not available in virtual quidditch. We model play-

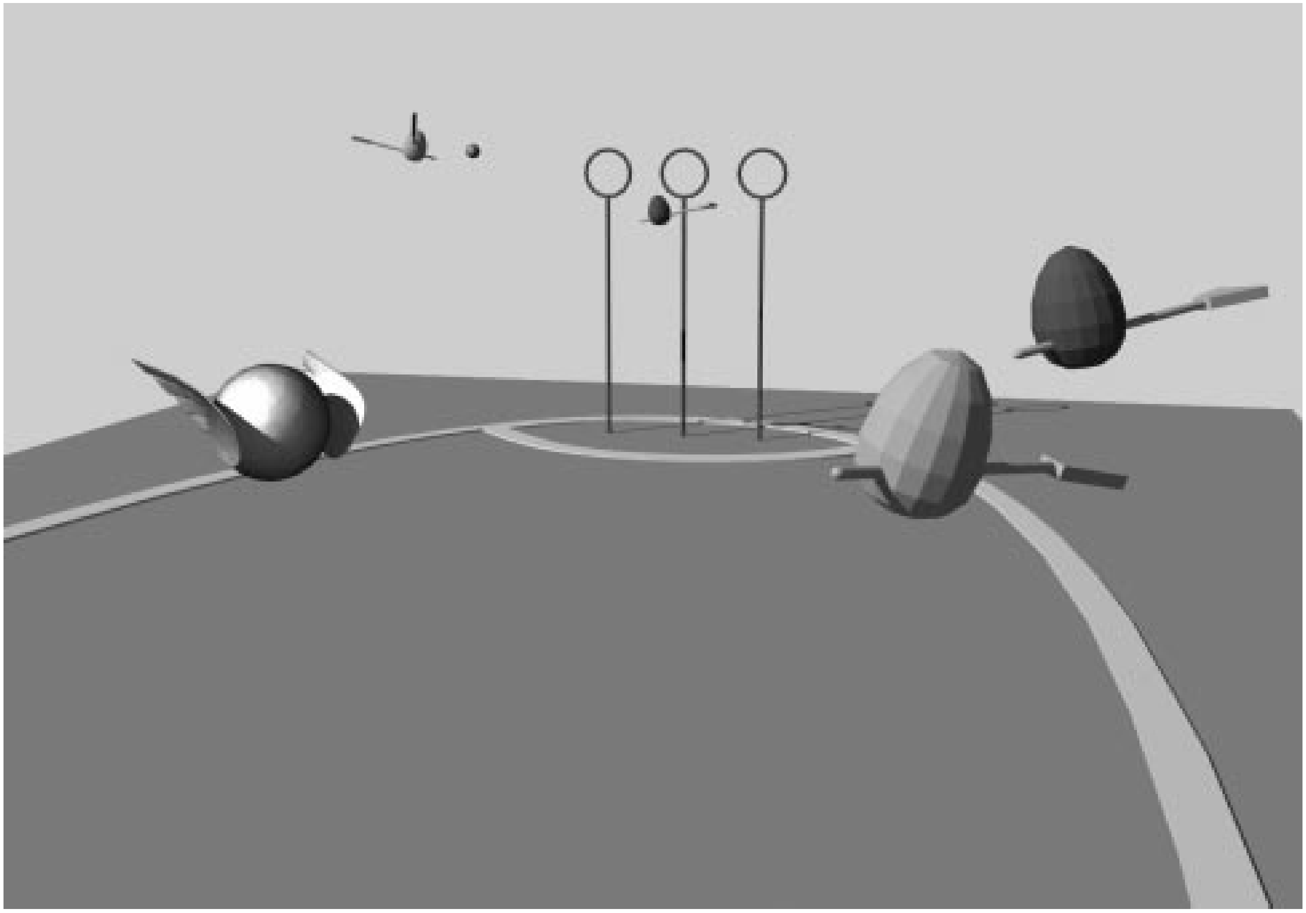

Figure 1: A view of the quidditch pitch including four players (a keeper, a beater, and two chasers), the golden snitch, a bludger, and one team's scoring area and goals.

ers as spheres with various bodily motions (hitting, catching, etc.) implemented as primitive actions.

The three chasers use the quaffle to try and score goals. They may throw the quaffle to each other as well as fly while carrying the quaffle. A chaser can enter the scoring area only while carrying the quaffle; if more than one offensive player is in the scoring area when a goal is scored then the goal is disallowed.

Two beaters on each team use bats to defend their teammates from the bludgers. They use these bats not only to block the bludgers but also to influence their direction. For example they may deflect a bludger towards members of the other team. It is not permissible, however, to deflect a bludger towards a keeper when the quaffle is inside the scoring area.

Finally each team has a seeker who is constantly trying to capture the golden snitch. The seeker is often the target of fouls as well as re-directed bludgers.

3.5 STARTING THE GAME

After all the players shake hands (simulated very coarsely, as the players have no hands), the referee stands in the two foot circle in the middle of the pitch surrounded by the 14 quidditch players. Play begins when the referee releases all four quidditch balls.

3.6 SCORING

When a chaser successfully throws the quaffle through one of the other team's three hoops, his or her team is awarded a goal worth 10 points.

3.7 TURNOVERS

Possession of the quaffle is automatically awarded to the other team when any of the following occur:

- the quaffle goes out of bounds with a chaser,
- the quaffle is thrown out of bounds by a chaser,

- a chaser misses a throw through a hoop, or
- the keeper intercepts a thrown quaffle.

Since a chaser hit with a bludger invariably loses grip (and therefore possession) of the quaffle, either team gains possession of the free quaffle by picking it up.

3.8 WINNING THE GAME

When the seeker catches the golden snitch, his or her team is awarded 150 points and game play ceases. A team wins by having more points than the other team after the snitch is caught.

3.9 STRATEGY

A team usually prevents the other team from scoring by stealing the quaffle from the other team's chaser (this is normally done by a chaser), by re-directing a bludger towards the chaser with the quaffle (this must be done by a beater), by intercepting a thrown quaffle, or by forcing the chaser with the quaffle out of bounds. Concerning the golden snitch, Carlson notes, "Since the catching of the golden snitch ends the game, if one team is ahead by more than 150 points, the other team's seeker tries only to keep the golden snitch from being caught until the score is closer. This may be the reason matches have been known to go on for as long as three months." (Carlson, 2001)

3.10 FOULS AND PENALTIES

Quidditch Through the Ages (Rowling and Whisp, 2001) describes several kinds of fouls and alludes to many more without spelling them out (allegedly because players who see them "might get ideas"). Not all of these are relevant to virtual quidditch or to our purposes. The following are the fouls that we currently plan to enforce in the first quidditch server:

- *Blagging* — Seizing another player's broom or any part of another player's anatomy.
- *Snitchnip* – Any player other than a seeker touching the golden snitch.
- *Stooging* – More than one chaser entering the scoring area.
- *Keeper Bumphing* – Deflecting a bludger towards a keeper when the quaffle is inside the scoring area.

Penalties for fouls may include penalty shots for the opposing team and/or point penalties. In a penalty shot a chaser flies from the central circle toward the goals, with defense provided only by the opposing keeper. The exact schedule of penalties for various fouls has not yet been determined for the quidditch server.

3.11 REFEREES

In Rowling's quidditch the rules are enforced by witches and wizards on broomsticks in the pitch alongside the players. The simulation of referees would add interesting features to the virtual quidditch by allowing, for example, a player to block a referee's view while another player on the same team violates a rule. The complexity of referee simulation was deemed to be too high, however, for the first version of the quidditch server. Rule enforcement is therefore handled by the server, which will act as an omniscient and perfect referee.

4 SERVER MECHANICS

Our quidditch server is modelled after the Virtual Soccerserver (Corten, et al. 1999) used for the RoboCup Simulation League competitions. The coordinates and velocities of all objects are 3-dimensional and continuous. The simulation progresses in discrete time steps, which do not have to be equivalent to wall-clock time when the simulation is being used for automatic programming runs. At each time step every agent can query the simulation for the information available from its sensors. It can then output a command specifying how the agent interacts with the world in the next time step.

The simulation represents a physically accurate world, but does not waste cycles on unnecessary details that do not significantly impact the dynamics of the game. Agents can sense details of the world, constrained by their perspective and location (agents cannot know what is happening outside their field of view), with details of what they see returned as angles and distances relative to the agent's location. The sizes of objects determine the distance from which they can be spotted (i.e., the goals can be seen from the other side of the field but the golden snitch can only be seen up close). Agents can interact with the world by issuing movement commands (with angles relative to their current headings, along with a speed), and commands to catch, deflect, or throw a ball in a specific direction (with a specified amount of force). Agents can also communicate with each other via shouted text strings, the volume of which determines the distance from which the agent can be heard.

Data is transferred between the simulation and agents via text strings that list the objects seen and the information sensed about those objects. (For a ball this is just its location; for a player this is its location and whether it is in possession of a ball, etc.). The text is passed in a Lisp list with a format similar to that used by the Soccerserver. For the fastest runtime evaluation (necessary when game play is used as a fitness metric for automatic programming) agents and the simulation exist in the same process. Communication, however, can be externalized such that the simulation can be accessed via externally bound modules or over a network connection.

5 FUTURE WORK

Our efforts to iron out the rules of virtual quidditch and to build a quidditch server are still in their early stages. Nonetheless it is already clear that this is a rich environment that will provide fertile ground for the development (by hand or by automatic programming methods) of intelligent, adaptive software agents. When our server is complete we will make it publicly available and invite other researchers to build teams of quidditch-playing agents that can be tested in server-based competitions.

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The rules of quidditch described in this document have not been authorized by J. K. Rowling or by the Department of Magical Games and Sports.

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