School of Computer Science and Information Technology
University of Nottingham
Jubilee Campus
NOTTINGHAM NG8 1BB, UK

Computer Science Technical Report No. NOTTCS-WP-2002-1

A history of the Tileworld agent testbed

Michael Lees

First released: March 2002

A history of the Tileworld agent testbed

Michael Lees

March 19, 2002

Abstract

This paper looks at the history and development of an agent testbed called Tileworld. It defines the original testbed and documents its gradual development up to its current form. It also introduces some of the experiments performed using Tileworld and their results. It concludes with a comparison of Tileworld with other agent testbeds and a look at agent testbeds as a whole.

Tileworld - A History

Tileworld was initially introduced in [Pollack and Ringuette, 1990] as a system with a highly parameterised environment which could be used to investigate reasoning in agents.

The original Tileworld consists of a grid of cells (squares) on which various objects can exist. These objects can be anyone of the following, agents, tiles, obstacles and holes. The agent (about which the experiment is based) can move up, down left or right. The agents objective is to pick up and move tiles so as to fill the holes. A hole has an associated point value which is awarded to the agent upon filling the hole. Each hole varies in size and point value, so a hole may consist of three cells on the grid and have a total point value of five. Once the hole is filled completely the agent gains the points. The agent knows how valuable each hole is in advance; its overall goal is to get as many points as possible.Tileworld simulations are dynamic, the environment changes continually over time. The objects appear and disappear at rates pre-determined by parameters in the simulator.

The first use of Tileworld as a testbed was in [Pollack and Ringuette, 1990] in which it was used to test the IRMS architecture [Bratman et al., 1988]. Following the initial experiments in [Pollack and Ringuette, 1990] tileworld was shown to be a viable testbed for evaluating agent architectures. In [Kinny, 1990] Kinny investigates various simulated worlds and sets out four properties an idealised simulated world should have.

- A set of objects and events sufficiently rich to embody "interesting" aspects of real environments

- A metric of agent performance that is convenient to use, i.e. simple to calculate, yet sufficiently fine-grained to allow adequate discrimination of effectiveness
- A set of parameters that vary the interesting properties of the world. Ideally the parameters would map to well-defined measurable properties of real environments.
- The ability to randomly generate large numbers of statistically similar worlds.

Upon comparison with the Phoenix [Cohen et al., 1990] and GridWorld [Boddy and Dean, 1989] he felt Tileworld came closest to satisfying these four properties. Some simplifying assumptions were made during the experiments, the most important of these in terms of Tileworld was that the world would in fact contain no tiles. Their version of Tileworld had no tiles, agents would score points by simply going to a cell that contained a hole. Even with this simplified version of Tileworld the resulting system enabled the authors to construct a highly parameterised class of agents and environments. Which they used to investigate how commitment to goals contributes to effective behaviour and to compare the properties of different strategies for reacting to change.Kinny went on to use this simplified version of Tileworld a second[Kinny and Georgeff, 1991] and third [Kinny and Hendler, 1992] time to investigate agents without perfect zero-cost knowledge of their environment.

Al-Badr and Hanks [Al-Badr and Hanks, 1991] investigated the Tileworld program in detail. They examined the program, its claims and the experimental results in the initial Tileworld paper [Pollack and Ringuette, 1990]. Their conclusions indicated that the validity of Tileworld rests on a strong methodological assumption;

> that testing and validation consists of parameterising the environment and agent, and then testing the agents performance for various combinations of these parameters.

Al-Badr and Hanks had shown that Tileworld was in fact too simple, they proceeded to point out various features of the real world (interesting to researchers) which could not be studied using the Tileworld simulator.

Following its criticisms Tileworld was enhanced in [Pollack et al., 1994] to support a wider range of experiments. The system was extended in three ways;

- Agents were given a fuel level which they were responsible for maintaining. This enabled the study of maintenance.
- To enable agents to maintain their own fuel a gas station was added to the environment. Another top-level goal of building stock-piles of tiles having particular shapes at strategic locations was added.
- Tiles and Holes were assigned shapes, so that filling a hole with a tile of the same shape achieved a higher score than filling with a tile of a different shape. Agents could also carry more than one tile - which would cause them to burn more fuel.

In answering some of the criticisms [Pollack et al., 1994] also stated

> However, we think one of the strengths of the Tileworld is its conceptual flexibility: we have found that it is relatively easy to design Tileworld

> modifications that support experiments that investigate environmental and agent design issues other than those for which it was originally designed.

This though raises the question of validity of modification. Modifying Tileworld to meet the needs of the experiment has the danger of modifying to meet the needs of the results. If the designer makes assumptions about what the interesting aspects of tileworld are and omits the uninteresting-interesting aspects there is a danger of over looking an important part of the agents design. A similar issue was also raised in [Al-Badr and Hanks, 1991], isolating interesting aspects of the problem to work on, has the effect that a good agent performance (with regard to these aspects) will not guarantee a good general agent.

Pollack *et al* used the revised Tileworld in [Pollack et al., 1994] to investigate commitment strategies in dynamic environments, in particular, filtering. They attempted to replicate results of [Kinny and Georgeff, 1991] in a slightly more complex environment. Which showed that for a wide range of Tileworld environments, filtering is a good strategy. Hitoshi Iba used genetic programming to develop agents in the Tileworld environment [Iba, 1999].

Following the revision of tileworld Pollack, Ephrati and Ur went on to develop a multi-agent version of the system called MA-tileworld [Ephrati et al., 1995]. Each of the agents behaves in the same way as the agent from the single agent tileworld, agents are awarded points for filling holes with tiles. Pollack, Ephrati and Ur used the new MA-tileworld to investigate filtering strategies with multi-agent systems.

Why Tileworld?

Testbeds in general have been the target of much criticism [Al-Badr and Hanks, 1991], [Hanks et al., 1993]. In [Hanks et al., 1993] a number of issues are raised about the appropriate use of testbeds (and benchmarks).

> 1. Benchmarks and testbeds no more guarantee important results than, say microscopes and bunsen burners. They are simply part of the apparatus of empirical AI.
> 2. There is little agreement about what is a *representative* benchmark or testbed problem.
> 3. Results obtained with benchmarks and testbeds often are not general
> 4. There is a real danger that researches will aim for the prescribed benchmark target when funding is perceived as the reward.

Although testbeds are affected by these issues, if used carefully however testbed can have an important role to play in agent design. It is often the case that researches have no other means of testing their agents, without a testbed there is no way of empirically investigating their agent(s). Using Tileworld as a testbed offers many advantages. Tileworld is essentially a very simple environment, but sufficiently interesting to draw conclusions from an experiment. There are obvious advantages of having a simple environment in which to test your agent, it makes the problem

smaller and easier to evaluate. A simple environment is always a good starting place for initial experimentation.

Tileworld is also highly parametrised, the experimenter can alter various aspects of the environment, for example change the rate at which objects appear and disappear. This makes it possible to tune the experiments to examine particular aspects of interest. In [Pollack and Ringuette, 1990] various "knobs" are controlled for experimentation, these are

- *Dynamism* - The rate at which new holes appear
- *Hostility* - The rate at which obstacles appear
- *Variability of utility* - difference in hole scores
- *variability of difficulty* - differences in hole sizes and distances from tiles
- *Hard/Soft bounds* - Do holes have a set or gradually decaying lifetime

Using these parameters Pollack and Ringuette were able to investigate how the rate of change in the environment affected the effectiveness of filtering. Kinny and Georgeff also varied the rate of world change for their experiments in [Kinny and Georgeff, 1991].

Another advantage of using Tileworld is that it is well-understood. It is possible to compare results obtained from similar experiments using the same environment. This is important when experiments are in the early stage, it is possible to obtain an indication of how feasible what one is attempting is.

However, one of the strengths of Tileworld is also a weakness [Anderson, 1995], the simplicity limits its use. If an agent performs poorly in tileworld it might be the case that the same agent performs exceptionally in another more complex environment. The conclusions drawn from results of Tileworld experiments must be specific to the attributes studied, generalising the results wouldn't be valid. Care must be taken when deciding what aspects of the system to study, it may be the case that it isn't possible to study these aspects using Tileworld [Al-Badr and Hanks, 1991].

References

[Al-Badr and Hanks, 1991] Al-Badr, B. and Hanks, S. (1991). Critiquing the tileworld: Agent architectures, planning benchmarks, and experimental methodology. Technical Report TR 91-11-01.

[Anderson, 1995] Anderson, J. (1995). *Constraint-Directed Improvisation for Everyday Activities*. PhD thesis, Department of Computer Science, University of Manitoba.

[Boddy and Dean, 1989] Boddy, M. and Dean, T. (1989). Solving time-dependent planning problems. Technical Report CS-89-03.

[Bratman et al., 1988] Bratman, M. E., Israel, D. J., and Pollack, M. E. (1988). Plans and resource-bounded practical reasoning. *Computational Intelligence*, 4(4):349–355.

[Cohen et al., 1990] Cohen, P. R., Greenberg, M. L., Hart, D. M., and Howe, A. E. (1990). Real-time problem solving in the phoenix environment. Technical Report UM-CS-1990-028.

[Ephrati et al., 1995] Ephrati, E., Pollack, M., and Ur, S. (1995). Deriving multiagent coordination through filtering strategies. In Mellish, C., editor, *Proceedings of the Fourteenth International Joint Conference on Artificial Intelligence*, pages 679–685, San Francisco. Morgan Kaufmann.

[Hanks et al., 1993] Hanks, S., Pollack, M., and Cohen, P. (1993). Benchmarks, testbeds, controlled experimentation, and the design of agent architectures. *AI Magazine*.

[Iba, 1999] Iba, H. (1999). Evolving multiple agents by genetic programming. In Spector, L., Langdon, W. B., O'Reilly, U.-M., and Angeline, P. J., editors, *Advances in Genetic Programming 3*, chapter 19, pages 447–466. MIT Press, Cambridge, MA, USA. Forthcoming.

[Kinny, 1990] Kinny, D. (1990). Measuring the effectiveness of situated agents. Technical Report 11, Australian AI Institute, Carlton, Australia.

[Kinny and Georgeff, 1991] Kinny, D. and Georgeff, M. (1991). Commitment and effectiveness of situated agents. In *In Proceedings of the Twelfth International Joint Conference on Artificial Intelligence (IJCAI-91)*, pages 82–88, Sydney,Australia.

[Kinny and Hendler, 1992] Kinny, D. and Hendler, J. (1992). Experiments in optimal sensing for situated agents. In *In Proceedings of the Second Pacic Rim International Conference on AI (PRICAI-92)*.

[Pollack et al., 1994] Pollack, M. E., Joslin, D., Nunes, A., Ur, S., and Ephrati, E. (1994). Experimental investigation of an agent commitment strategy. Technical Report 94–31, Pittsburgh, PA 15260.

[Pollack and Ringuette, 1990] Pollack, M. E. and Ringuette, M. (1990). Introducing the tileworld: Experimentally evaluating agent architectures. In *National Conference on Artificial Intelligence*, pages 183–189.

This research was supported by a grant from the Engineering and Physical Sciences Research Council (Project No. GR/R45338/01)