# Capturing the Quake Player: Using a BDI Agent to Model Human Behaviour

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## ABSTRACT

The BDI agent framework is a well-known agent framework, often discussed in the agents literature. The work described here takes advantage of the folk psychological roots of the philosophical underpinnings of BDI to develop and build models of human behaviour. Knowledge elicitation was closely tied to the folk psychological background, and this was then encoded with a BDI-based language. Although some accommodation did have to be made for the gaps between the BDI philosophy and the implementation language, this approach did provide intuitive way of developing and building these models.

## Categories and Subject Descriptors

I.2.11 [**Artificial Intelligence**]: Distributed Artificial Intelligence—*Intelligent Agents*

## General Terms

Algorithms, Design, Human Factors

## Keywords

Human-like Characters, User Modelling, BDI Agents

## 1. INTRODUCTION

Modelling human users is a natural application area for agent technology. Agents are intended to be situated within an environment and act autonomously within that environment, and people are the archetype for autonomous action. The work described here uses BDI agents to model expert human players of the commercial game, Quake 2. It is argued that BDI agents are particularly suited to human modelling because of their folk psychological basis, and this is demonstrated through building models of expert Quake 2 players.

The approach taken was to use a knowledge elicitation methodology that mapped closely to the philosophical underpinnings of BDI, and then encode this knowledge using JACK Intelligent Agents. (Space constraints prevent an explanation of the BDI framework here. Readers unfamiliar with the concepts should refer to Wooldridge's excellent introduction [4, Ch. 2].) The underlying philosophy of the BDI framework – based in folk psychology, the way people *think* that they think – maps closely with the way that people ordinarily explain their reasoning, facilitating knowledge capture. Although there are gaps between the philosophy and implementations of the BDI framework, there are two good reasons for tying the knowledge elicitation more closely to philosophy than implementation. The first is that the knowledge is then reusable in other BDI-based languages, which may have different limitations. The second is that highlighting the shortcomings of the language in this way can motivate change in the implementation, narrowing the gaps and ultimately making the language easier to use.

This paper briefly outlines the problem being tackled with this work, and some of the results. Readers are encouraged to attend the poster session at the conference or contact the author directly for a more detailed description of the work.


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## 2. MODELLING HUMAN BEHAVIOUR

Human modelling has a wide range of applications, from testing and evaluation (e.g. of user interfaces), to operations analysis and training. For testing and evaluation and operations analysis, it provides test subjects who can repeat the experiment(s) endlessly without suffering fatigue or boredom, with repeatable results. For training, it is particularly valuable in safety-critical domains, where a mistake in the real world may have catastrophic results, but a simulated environment gives the designer or trainee a safe place to explore. In this case, human modelling can be used to represent the other humans in the environment, saving the expense of role-playing participants.

The difficulty of course is in generating "good" human models. The definition of "good" is highly dependent on the application: in some cases, simple cellular automata may be appropriate, while in others, sophisticated cognitive models may be required. The work described here was inspired by research at Australia's Defence Science and Technology Organisation (DSTO), where agent-based simulation has been used for operations analysis for several years. The success of the initial work has led to wider interest in agent-based simulation within DSTO, with demands for more sophisticated models.

### 2.1 Why Quake 2?

While DSTO have a number of simulated environments that could be used for testing agent-based human models, they are not particularly accessible, both for security reasons, and because of the hardware required to run them.

Quake 2 on the other hand is a commercial off-the-shelf multi-player game with a detailed simulated environment. It requires very little in the way of computational power, and is easily accessible by the broader community. The environment is complex enough to be able to explore a range of human behaviours, and subject matter experts are easily accessible.

## 2.2 Why BDI?

It is because the philosophy of the BDI framework has its foundations in folk psychology that it proves to be useful in capturing human knowledge and reasoning for specific tasks. When asked about how they think about a problem, people already have a tendency to explain their actions in terms of what their intentions were, which in turn are explained in terms of their goals and beliefs. Moreover, when they describe the ways in which they try to achieve goals (i.e. the plans that they use), they will do this in a hierarchical manner, which maps to the partial plans needed to construct a plan library for a BDI agent. Extracting this information from people does require careful planning and structured questioning, but the fact that model builder and the subject being modelled are referring to the same concepts does simplify matters.

# 3. KNOWLEDGE CAPTURE

The knowledge elicitation methodology used was a slightly modified form of Applied Cognitive Task Analysis (ACTA) [1], developed by Klein and Associates in the context of interface design and training. ACTA was designed to capture the *reasoning* of expert operators, rather than the procedures that they use to perform their job. The captured knowledge was then used to design user interfaces that supplied the necessary information, and training manuals and programs that taught novices understanding of their job, rather than simply a set of procedures to follow.

ACTA consists of a series of semi-structured interviews, with probes designed to understand *why* a person does something, rather than simply just what he/she does. One stage of the interview process focuses on the difference between novice and expert behaviour, and the reasons for it, while another typical stage is a simulated scenario, where the expert is talked through a scenario and asked at various points what they would do and why.

In the work described here, three different players were modelled, each having a playing style that was quite different to the others.

# 4. IMPLEMENTATION

The knowledge elicited in the above manner was relatively easy to translate into JACK code. High-level strategic differences between the players were clearly and succinctly expressed. There were some language-specific issues that needed work-arounds, most notably the lack of explicit representation of goals. Using JACK, once a plan has been selected to achieve a goal, there is no way to reason about the goal. If for example the opportunity arose for a better way of achieving the goal, there is no inbuilt way of detecting this. Similarly, there is no way of detecting if a new goal will cause conflicts with another goal that the agent is already committed to achieving.

The major difficulty in implementing these agents was not a language-specific one: it was that neither the knowledge elicitation method nor the BDI framework are not equipped to deal with low-level skills and behaviours. Both ACTA and BDI are about the way people *reason* about a task. Neither considers the physical actions and sensors used to perform the task. While it was possible to capture high-level skill differences between players, the methodology and framework could not be used to capture low-level skills, such as aiming accuracy, and similarly, there is no prescribed way for an agent to sense the environment. Should all the input from the environment automatically become beliefs, or should the agent actively reason about sense data and selectively store beliefs? Such issues are not unique to BDI, and other cognitive modelling languages such as Soar and ACT-R have extensions which model perception and action. Based on the Soar implementation, a preliminary model has also been implemented in JACK [3].

# 5. ONGOING AND FUTURE WORK

While the BDI paradigm has been useful in capturing expert knowledge, it is a highly abstracted representation of human reasoning. In some situations human behaviour is highly influenced by certain aspects of cognition, such as processing speed or working memory capacity. In these situations it may be necessary to explicitly model certain aspects of cognition that are glossed over in the BDI framework. The ongoing work is looking at the effect of incorporating a naturalistic decision-making strategy into the agents, and whether this improves the perceived “human-ness” of the Quake 2 playing agents [2]. In theory, agents are usually assumed to use utility-based decision making strategies, and in practice they usually use satisficing strategies. The ongoing work has taken a descriptive model of decision-making developed from on-the-job studies, and incorporated this into the JACK framework. The agents are evaluated by expert players, who interact with the models of the three Quake 2 players, built using the standard decision-making in JACK, and using the enhanced decision-making strategies.

Future work will look at an extension to JACK that aims to retain the intuitiveness of the BDI architecture while incorporating more specific cognitive elements into the framework, such as working memory capacity or processing speed. This extension will then be used to explore the representation of behaviour moderators – external effects such as heat and noise, as well as internal moderators such as emotional state and fatigue – in the context of military simulation.

# 6. REFERENCES


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