Penerbit Akademia Baru

Journal of Advanced Research in Applied Sciences and Engineering Technology
ISSN (online): 2462-1943 | Vol. 2, No. 1. Pages 1-8, 2016

Data Visualisation Self-Explanatory Systems in Intelligent Game Inference Engines

A. Chiou

School of Engineering & Technology, Central Queensland University, Rockhampton 4701 Queensland, Australia
a.chiou@cqu.edu.au

Abstract – *This paper proposes a method that provides the mechanism for a game AI (artificial intelligence) to communicate its evaluation processes using data visualisation and descriptive and explanatory functions. A case study will be presented that includes an implementation of a game AI opponent that is capable of describing its inferential processes while playing a tabletop wargame.*

Keywords: Game AI, Board games, Explanation, Data visualisation

1.0 INTRODUCTION

The main purpose of computer games is to provide entertainment and pleasure to the consumers. However, there are also computer games that can be regarded as belonging to the serious game genre. These games, in addition to providing the entertainment and pleasure value, also impart the value of learning to the players involved in the current game's subject matter. For example, in the game of chess, it is normal for players to proceed into an analysis phase once the game has been completed. This is to allow players and interested parties to determine if alternative moves could have been considered to produce a different outcome. In current implementation of popular computer chess playing software, the game AI is capable of annotating and commenting on its own and the opposing player's moves. It is also able to provide advice and suggestions on what future moves to consider or to execute. The information is conveyed to the [human] players using textual semantics (i.e. written language) and a set of universal language-independent symbols (Figure 1) to indicate its intended meaning.

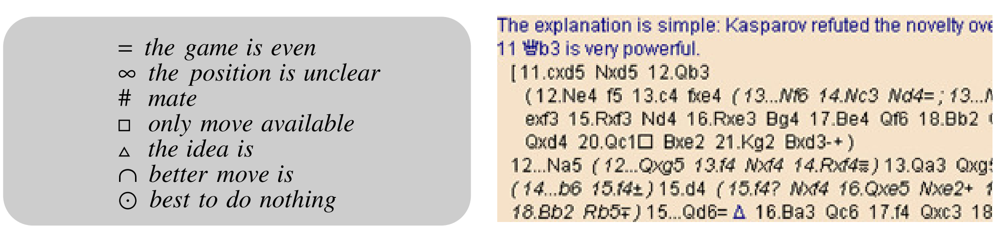

Figure 1: Example of universal symbols used to annotate chess games (left) and a game fragment of an actual chess game auto-annotated by computer chess software, Fritz (right).

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Contemporary strategy wargame-based tabletop games can consist of hundreds of hexes and playing pieces (e.g. *Tide of Iron*, *War to Axis*). It is with the intention of providing game AI with similar ability to self-annotate and express the outcome meaningfully to [human] players that necessitates a mechanism that allows this to be developed. This paper focuses on the workability of such a provision to allow the game AI to convey its 'thoughts' effectively to the players.

2.0 BACKGROUND

Previous research has indicated that computerised solutions provided by intelligent systems accompanied by an explanation or justification can make these recommendations more acceptable to end users [2-4]. Due to the hybrid nature of the knowledgebase, data types in the game AI production shell, an explanation may not necessarily be implemented in a primarily textual context. To handle all data types, the self-explanatory module in the application is implemented as self-explanation capability using data visualisation. The data visualisation is to facilitate the game AI engine to allow it to communicate with the human players effectively. Data visualisation of qualitative data and information gathering is well established in areas of ethnography [5-8].

The theoretical base for explanation function in conventional expert systems and its construction is explained in [4]. In the specific objectives of the proposed application, it is practical to extend textual explanations in conjunction with other forms of expression as part of its functionality. In addition to textual explanation, the application should also be required to explain its inferential process using non-textual presentation. Therefore, a provision is made to include descriptive data visualisation into its explanatory capabilities.

3.0 IMPLEMENTATION

This section will detail the technical implementation of the textual explanatory capability and the proposed schema. This extends previous work in [1].

3.1 Descriptive Explanation

The mechanics of REST3 (Rule Explanation for Expert Systems Using Service Tags, Tables and Tracing) employ the use of service tags to keep a linear rule trace of all relevant If-Then rules that have instantiated as a result of an ongoing inferential process. All rules in the knowledgebase have a tag appended to each completed If-Then statement. These tags do not influence nor play any part in the inference process of the system. Its primary purpose is only to provide a pointer to the tables used in REST3. These tables will hold all relevant discourse material that will subsequently be consolidated to provide the explanation and justification for the final recommendation.

Descriptive schemas are generated as a series of symbols. These symbols will inherently provide qualitative data to represent numerical data that has been defuzzified as a result of a previous inferential process as in Figure 2. In this example, the original input values are x_1, x_2, … x_n into the fuzzy RHS consequent membership values. The appropriate rules will fire, therefore generating the final composite consequent, y_1, y_2, … y_n, for each of the fuzzy DOF. At this junction, instead of a final defuzzied value, the value is mapped against the appropriate

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schematics. Also note that every instantiation of rules within the system will generate a REST3 tag file at points A, B, C and D. This implementation uses the fuzzy meta-consequent post adjustment technique described in [9].

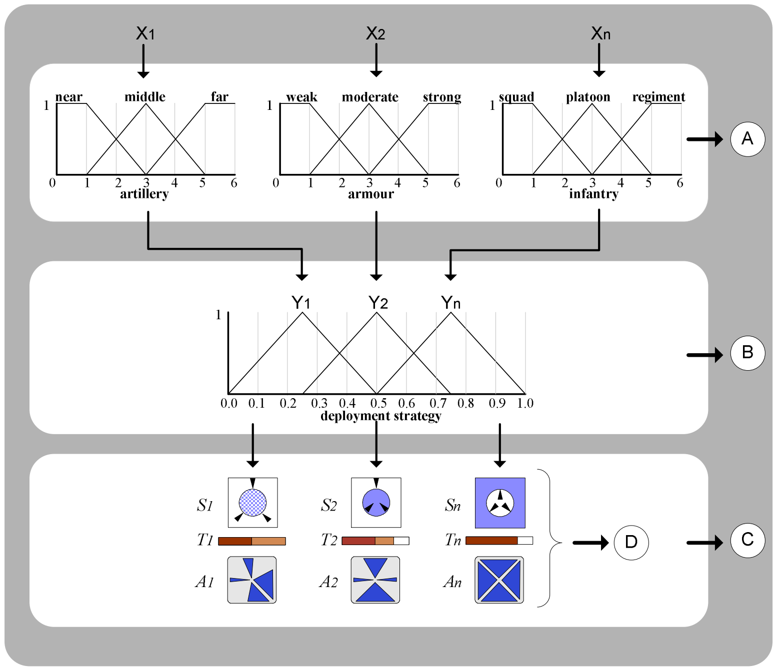

Figure 2: Descriptive schema as a result of a defuzzifying process post adjustment functions. Note at each inferential phase, the REST3 are generated at A, B, C and D.

There are three types of schemas applied to the GAIA application in providing meaningful advice and suggestions to game players. These are type S, T and A. Each respectively represents deployment strategy, confidence threshold and directed action. The symbols and its purpose will be explained in the section on case study. In this way, complex advice such as, "Infantry units can be deployed surrounding, but not within the objective area", can be conveniently expressed. Conversely, a similar output using conventional numerically based data would have been complex and cumbersome.

3.2 Case Study

Memoir '44 is a strategy-based wargame played on a hex/tiles game board (Figure 3). It is a turn-based game for two players. The objective of the game is for players to take the role of either an axis or allies military force in order to accomplish specific goals (e.g. secure area of conflict, destroy enemy forces, etc.). The hex-based playing board is reconfigurable to allow different historical battlefield scenarios to be re-created. Different types of resources are available to both players. These are infantry, armour and artillery units. By judicious deployment of these units, players will attempt to defeat the opposition with minimal lost to its own units.

Figure 3: Memoir '44 setup. Note the two mobile devices used to display the GAIA module consultation.

4.0 RESULTS

GAIA identified four critical sectors, numbered 1, 2, 3 and 4 in Figure 4 from the viewpoint of the axis player. It correctly include the two main objectives of the mission (i.e. the two bridges) labeled 1 and 4. As for the other two sectors, numbered 3 and 4, these were later identified to be strategically important for accomplishing the primary objective. For each of the critical sectors identified, GAIA provided three types of descriptive schema and explanation detailed in the following sections.

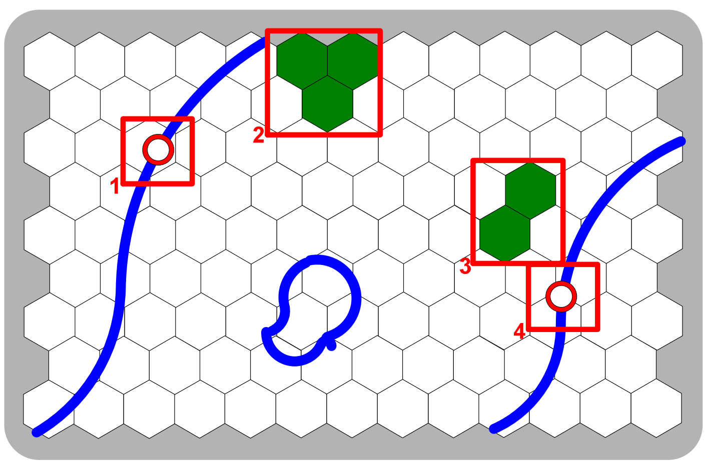

Figure 4. Historical wargame scenario in the case study. The mission is to capture the bridges indicated by red circles.

4.1 Type S: Deployment Strategy

Each deployment strategy schema has an inside and outside region designated by a boundary (i.e. circle). The shade of colour (i.e. blue) in any of the two regions indicates the relative

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importance of the critical zones identified. In zone 1 and 4, the darker shade within the circle and the complete absence of blue outside the circle implies that the two zones are of utmost importance. The arrowhead indicates if forces should direct their attack for or against these zones. In both 1 and 4, the axis forces are expected to defend the two bridges, indicated by arrows pointing outwards. As for zone 2, forest terrain provides cover for the axis force and therefore the axis player should defend it. However, in 3 where the opposing force is found to be hiding, the deployment strategy here is to attack against it as indicated by the reversed arrowheads. Also, note that the darker shade of blue outside the circled boundary. This indicates that the areas outside the forest terrain are of more importance than within.

4.2 Type T: Confidence Threshold

In addition, each deployment strategy schema is complemented by an impact meter to indicate the *confidence threshold*. This meter provides the confidence level required by players to ensure that the deployment strategy advice by GAIA is sound or unsound against the predicted effectiveness if it were to have actually taken place. Darker shade readings indicate that the effectiveness of the deployment strategy is *guaranteed*. The lighter shade indicates a *probable* level of effectiveness.

The schematic for confidence threshold is only meaningful when associated with the relevant deployment strategies inferred previously for each of the critical sectors in Figure 5. The threshold for critical sector 1 and 4 can be guaranteed to be up to 80% effective. As for sector 2, the threshold is a low 25-50% as it is basically a forest terrain and therefore difficult to defend. As opposed to critical sector 3, where the deployment strategy is to attack against the units hidden in the forest terrain, the potential impact is expected to be 50-66% effective.

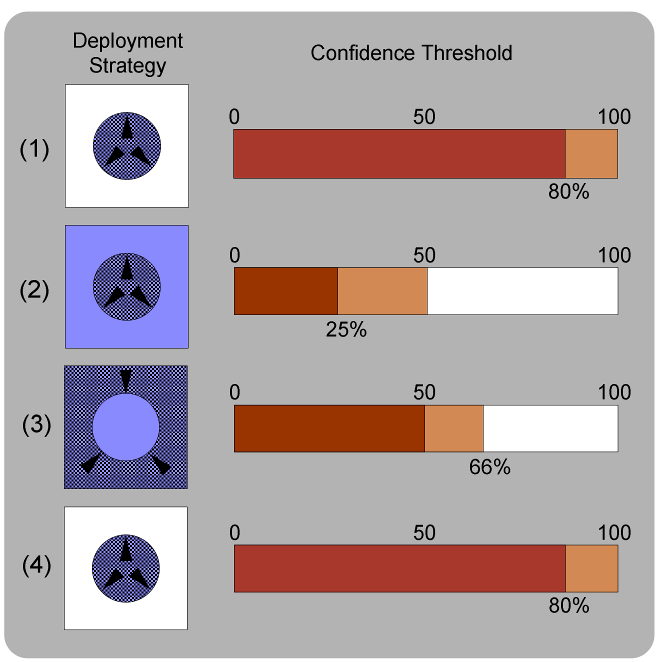

Figure 5: Deployment strategies, with corresponding confidence threshold for each of the relevant critical sectors indicated in Figure 4.

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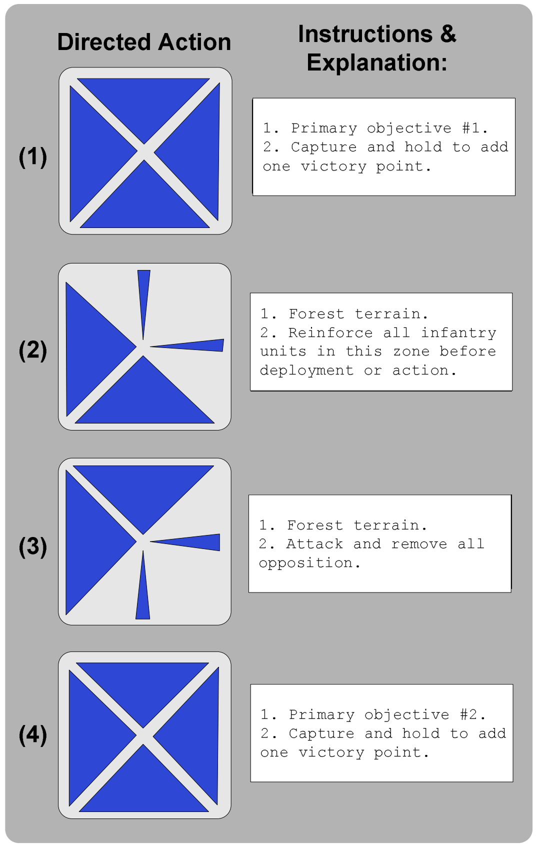

Figure 6: Direct actions for each critical sector with corresponding textual explanatory discourse resulting from the REST3 mechanism.

4.3 Type A: Directed Actions

Recommended actions uses a different set of symbolic schema to indicate *how* an action is to be taken based on the control strategy. As the *directed actions* to be taken (e.g. call for support, defend, attack, etc.) can involve large coverage within the game board, this cannot be carried out arbitrarily even if the impact meter indicates a very high level of effectiveness. Note that a deployment strategy and actions taken to implement the strategy are factors that are mutually exclusive. An optimal deployment strategy does not necessarily guarantee a high level of success if a less appropriate action has been taken to implement it (e.g. using firearms against a tank instead of anti-tank mines). Therefore, the application of each action needs to be indicated directionally to maximise the effectiveness of the deployment strategy and its combined actions.

To simplify the representation of the recommended actions and to maintain the symbols at a practical and useable level, approximation of the concentration of force along each compass direction or particular arcs corresponding to the critical zones is taken into account, while ignoring distances. For example, in Figure 6, the schema for sector 2 indicates that the actions should be primarily concentrated on the eastern and southern directions with minimal focus on the remaining directions. Recall that one of the primary objectives is located in the eastern-southern location of the game board. The GAIA module employs directed action schema in conjunction with textual instructions and explanations (with appropriate media, if available) to indicate what actions to take (Figure 6). This is the result of the REST3 mechanism described previously.

5.0 DISCUSSION

As shown in the test case, an implementation using descriptive schema and textual explanation can indeed help the user or the human player to comprehend the results of an inferred process. In development of game AI opponents, these functions can help designers to refine or tweak the game AI algorithm. With the schemata and explanation in place, it can facilitate and trace the decision making processes and help linear rule tracing.

6.0 CONCLUSION

This paper has demonstrated that in strategy-based games, it is sometimes beneficial to understand the inferential processes of the game AI opponent, e.g. What strategic or tactical motives is it inferring? Why did it make the previous move? This paper proposes a method that provides the mechanism for a game AI to communicate its evaluation processes using descriptive schema and explanatory functions. A case study has been presented that includes an implementation of a game AI opponent that is capable of describing its inferential process while playing a tabletop wargame.

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