Preface

Welcome to the annual Convention of the Society for the Study of Artificial Intelligence and the Simulation of Behaviour (AISB). We are delighted to host this in the year of the 50th anniversary celebrations of the University of Bath. AISB is the oldest conference in the field of AI, having been founded in Edinburgh 53 years ago.

This year, we as organisers chose to reinstitute the idea of a convention theme. We chose the topic of “Society with AI”. We wished to emphasise that AI is not science fiction that may or may not come in the future, but something here now, affecting us all. This theme is reflected in some, although of course not all, the various symposia and papers.

This year’s symposia are:

I Social Aspects of Cognition: Human and Artificial Life Symposium
II The Power of Immergence: Simulating language, decision-making and the evolution of culture
III Social Interactions in Complex Intelligent Systems (SICIS)
IV 4th Computational Creativity Symposium
V Computational modelling of emotion: theory and applications
VI Cognition And OntologieS (CAOS) 2017
VII The power of passion: Human reason and its emotional foundations
VIII AISB Symposium on Computational Architectures for Animal Cognition (CAAC)
IX AISB Symposium on AI & Games
X The 10th AISB Symposium on Computing and Philosophy: language, cognition, and computation

The symposia accepted the 71 papers which constitute these proceedings. This year seemed also to mark a phase transition for the AISB, as there were also a good number of contributed talks and demos which are not reflected in this proceedings, being published elsewhere. It is interesting to see AI becoming more like a natural science and less like a computer science in the drive to publish in journals and other venues; we are glad that the AISB meeting can bend to accommodate this, and thank again our symposia organisers for their creativity and flexibility.

Our theme is also reflected both in a special public plenary panel, and in the keynote talks in the plenary sessions starting each day. The panel, taking place at the end of the first day, is on the topic of “The Ethical Impact of AI on Society”. The panel is chaired by Alan Winfield (University of the West of England), with panellists Mandy Chessell (IBM), Nello Cristianini (Bristol), Danit Gal (University of Beijing) and Björn Schuller (Passau). The plenary talks are:
• Amanda Chessell “Ethics, algorithms, and the pursuit of human flourishing”
• Filippo Santoni De Sio (TU-Delft) “Meaningful Human Control Over Autonomous Systems”
• Björn Schuller “Artificial Emotional Intelligence – A Game Changer for AI and Society?”

The theme is put into practice and further strengthened in this edition of the AISB convention by reaching out to the wider community. The panel is free to members of the public due to generous and substantial support from the AHRC and the ESRC via David Galbreath (University of Bath), whom we gratefully acknowledge. We are also offering for the first time a free tutorial and hackathon day on “AI systems for society” to anyone interested, but with particular support from the businesses and programmers in the local technical community of the City of Bath and surrounds. Thanks again to the tutors; their topics are:

• Tools to support and research the Process of Policy Making, creating Online Deliberation environments supported by AI (Virginia Dignum, TU Delft)
• Reactive Planning for Robotics and Agent Based Models (Rob Wortham, University of Bath)
• Cognitive Systems for Automated Story Comprehension (Antonis Kakas and Loizos Michael, Open University of Cyprus)
• Generating Paths through Interactive Stories with Answer Set Programming (Matt Thompson, University of Bath)

The organizers thank the sponsors of this year’s convention (see over), our symposia and tutorial/hackathon organizers, our student volunteers and especially Kirstie Morrison, who went well beyond her two days of allocated time to help with the local administration.

The proceedings are organised by symposium, each of which is introduced by the symposium organizers.

We do hope you enjoy Bath and participating in the 2017 AISB convention.

Joanna Bryson, Marina De Vos, Julian Padget
(2017 convention organizers)
Bath, April 2017.
Sponsors

We are pleased to acknowledge support for AISB 2017 from:

[Logos of the sponsors]
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Symposium I

Social Aspects of Cognition: Human and Artificial Life Symposium

This Symposium (which is the continuation of the past AISB2015 and AISB2016) aims at stimulating a lively discussion on the social dimension of knowledge, behavior and ontology by crossing Philosophy, and AI. We point on the following topics (but not exclusively):

I. Strategies for analyzing the problem of the relationship between language, society and AI. Searle presented an interesting theory of representation based on the mind's capacities to represent objects and to the linguistic capacities to extend the representation to social entities. Brandom introduces compelling notion of representation in social terms and explores the differences between human and artificial mind. Moreover, we would like to focus on the issues of the embodiment and embodied cognition (Clark) and the role of social and bodily dimension in linguistic meaning in AI perspectives (Cangelosi et al., Minski). Emotions play a fundamental epistemological role in the “unspoken dimension”.

II. The later philosophy of Wittgenstein, classical pragmatism and contemporary analytic pragmatism provide fruitful conceptions of social practices. Social epistemology stresses on their role in human cognition to motivate the overcome of classical individual epistemology. Several important notions are analyzed (social behavior, social norms, testimony, etc.). McDowell and Davidson mention the role of the social within the process of acknowledgement. There are several examples of the bias between AI and human ability to react on various different problems, such as the problem of translation. Google translation generator is capable to of translating from one language to another only to certain extent. When it comes to larger textual corpus, Google ultimately fails to produce meaningful contents. What is it that human possesses and AI does not? Wittgenstein would perhaps call it a form of life, a social dimension. If human cognition is preconditioned by this social dimension, what this social dimension is? How does AI intelligence respond to these social precondition of human knowledge; or how is the absence of social aspect limiting for AI? What is it that human possesses and AI does not? Wittgenstein would perhaps call it a form of life, a social dimension. If human cognition is preconditioned by this social dimension, what this social dimension is? How does AI intelligence respond to these social precondition of human knowledge; or how is the absence of social aspect limiting for AI?

“Can sociological approaches rooted in cybernetics and systems-theory (Luhmann) give us a direction for analyzing, describing and constructing social systems inhabited by humans and machines?”

III. Interactions on social media such as Twitter or comment sections differ from “natural” dialogues in ways which present challenges for theories of discourse, dialogue and argumentation such as RST, SDRT or models influenced by Traum, Cohen & Levesque, Walton & Krabbe and others; as well as philosophical (Brandom, Habermas) semiotic (Eco) and linguistic (Crystal, Spilioti) approaches. On the one hand,
participation in online dialogue is typically fluid; interlocutors can join or leave a conversation without formality, it is problematic to assign distinct roles such as “addressee” or overhearer or 2nd vs 3rd person, participants may be unknown to each other and have only sparse models of each others backgrounds and beliefs. On the other, there may be direct access to participants’ posting history from which can be extracted a (possibly partial and/or inconsistent) “commitment store” in the sense of Hamblin or Walton & Krabbe.
Comparing question asking strategies for Cluedo

John Kingston

Abstract  The game of Cluedo – also known as Clue – requires working out a ‘murder’ scene by elimination. Beginners typically rely only on cards in their hand and cards they have seen; experts also use propositional logic about cards they have not seen, based on questions asked and answers given. A game-playing program has been written to test the value of using deductions to guide question-asking. This paper describes how the program has been designed and presents results for five strategies (including a ‘no intelligence’ strategy) for three player games and six player games. The program has been written using JESS (the Java Expert System Shell). The results were not quite as expected. Using propositional logic did indeed allow the game to be solved in fewer turns, but there were times when adding extra information to the logical deductions made things worse, not better. There is also a strong effect from the mechanics of the game – specifically, which room is chosen as the ‘guilty’ location – on the number of turns required to solve the problem. It is suggested that strategies might benefit from occasionally breaking away from their highly focussed approach to inject variety into the questioning

The test cases used are listed in an appendix.

1 INTRODUCTION

Winning a game of Cluedo – or ‘Clue’ as it is known in North America – relies on propositional logic. Each player holds some of the twenty-one game cards; in each turn they are allowed to ask for three named cards, and will be shown one of these cards by the next player – or, if the next player has none of the three, by the player after next, and so on. The task is to work out which three cards were put aside at the start of the game and so are not held by any player.

Beginners typically use exhaustive elimination: they keep playing until they have seen (or possess) eighteen of the twenty-one cards that represent possible suspects, murder weapons, or murder locations. Experienced players will also reason about cards they have not seen based on information gathered from questions asked by others.

The players’ goal is to work out which are the ‘murder’ cards either by exhaustive elimination or by asking for a card which they do not have in their hand and discovering that no-one else possesses it either. The minimum number of turns in which the game can be completed is therefore one turn if someone asks for all three murder cards in their first turn. The probability of such a guess varies between 0.5% and 1% depending on the number of players. Expert players make use of various sources of information apart from the cards that are shown on their turn. Such sources include logical information such as:

- Possible cards. If player X asks player Y whether s/he has cards A, B or C and player Y shows a card to player X, then every player can deduce that player Y holds at least one of A, B and C.
- Absent cards. If player X asks player Y for cards D, E and F and player Y passes, then player Y does not have cards D, E or F.
- Full hand known. If player X has seen or deduced every card in player Y’s hand, then player X knows that player Y does not have any of the remaining cards.

It is also possible to use ‘human’ information such as:
• Assuming that a beginner will always ask for three cards that are not in his hand.
• Assuming that a player who asked for cards A, B and C on turn 1 and D, B and C on turn 2 was shown card A on turn 1.

Finally, expert players will often manage the information that they share:
• If they receive a request for which they have two or more cards, they will prefer to show a card they have already shown to someone else.
• If they receive a request for which they have two or more cards, they will prefer to show a suspect or a weapon because rooms are the hardest to deduce.

The system described in this paper uses only the ‘logical’ information listed above. It offers five different strategies:

1. No intelligence: Choose cards to ask for at random, excluding only cards in the player’s hand and cards already seen. (In practice, the order is not random; it depends on the order in which the list of cards is uploaded into the system. This allows the creation of a diverse set of test deals which use cards from the beginning, middle or end of each of the three lists).

2. Deduction only. The system records each player’s knowledge of ‘possible’ cards held by other players, and also of cards that other players do not hold. If there is a set of three ‘possible’ cards and a player knows that two of them belong to somebody else, or are on the ‘not held’ list, for a player, it can deduce that a player must hold the third of those three cards. Its question asking strategy is not to ask for cards in hand, cards seen, or cards deduced.

3. Next–possible: If a ‘possible cards’ list is available for the next player, choose one of those (excluding cards in hand, cards seen, cards not held and cards deduced) along with two other cards to ask about. Preference is given to asking about the room. The goal of this strategy is to confirm the cards held by the next player.

4. Previous–possible: If a ‘possible cards’ list is available for the previous player, choose one of those (excluding cards in hand, cards seen, cards not held and cards deduced) along with two other cards. Preference is given to asking about the room. The goal of this strategy is to reduce the options for opponents to hide cards; since all but one are likely not to have the ‘possible card’, they will find it more difficult to conceal either of the other two requested cards.

5. Next–not–held. If some cards are known to be absent from the next player’s hand, ask about one or two of these (with the same exclusions as for strategies 2-4). The preferred strategy is to choose two cards not held by the next player, along with one card not held by the player after next; failing that, the system chooses two cards not held by the next player and one other; failing that, it chooses one card not held by the next player and two others. The goal is to search for a possible solution by finding cards that no other players hold; asking about cards that some players are known not to hold shrinks the search space.

For strategies 2-5, if there are no cards that fit into the strategy’s rules, the fallback is to use the ‘no intelligence’ strategy.

3 RESULTS

The strategies were run on six different test ‘deals’ between three players and the same ‘deals’ split in half for six players. Every player used the same strategy in any one game. The full ‘test deals’ (for 3 player games) are listed in Appendix 1 in case anyone wants to repeat the experiments described in this paper. Then, for completeness, a generator was used to run the strategies on every possible deal (or to be precise, on every possible combination of ‘guilty’ cards, swapping cards in and out of existing hands as needed).

The test deals were designed to vary the position in the list of cards of the ‘murder’ cards. The ‘murder cards’ for the six deals were:

1. Professor Plum, Lead Pipe, Hall. Plum is the 6th and final person in the list of suspects; Lead Pipe is listed fourth in the list of six weapons; Hall is listed as the first of the nine rooms. This will be represented as [6, 4, 1].
2. Professor Plum, Spanner, Kitchen [6, 6, 9]
3. Mrs White, Rope, Ballroom [3, 3, 5]
4. Miss Scarlett, Rope, Kitchen [1, 3, 9]
5. Mrs Peacock, Spanner, Dining Room [2, 6, 2]
6. Miss Scarlett, Revolver, Hall [1, 1, 1]

Because JESS tends to work sequentially down a list when pattern matching, the following predictions can be made:
• Deal 2 will take the longest to solve
• Deal 6 should be solvable in 1 turn
• The other four deals should take approximately the same time to solve, with deal 5 perhaps marginally the fastest and deal 4 marginally the slowest.

Predictions can also be made about the strategies:
• Since the intelligent strategies fall back to the No-Intelligence strategy when they have no legal move, it is very unlikely they will do any worse than the No-Intelligence strategy
• The Deduction strategy should perform the best of the four ‘intelligent’ strategies since it uses the least information.
• The other strategies should have a bigger advantage over the first two strategies in longer games, since more and more information becomes available as games go on.

The total number of rounds required to find a solution is shown in Table 1, excluding Deal 6 which was always solved in 1 turn as predicted.

<table>
<thead>
<tr>
<th>Deal</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>All</th>
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<td>12</td>
<td>6</td>
<td>7</td>
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<tr>
<td>Deductions</td>
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<td>6</td>
<td>7</td>
<td>4</td>
<td>6.07</td>
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<tr>
<td>Next-possible</td>
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<td>13</td>
<td>5</td>
<td>11</td>
<td>3</td>
<td>6.55</td>
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<tr>
<td>Previous-possible</td>
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<td>11</td>
<td>5</td>
<td>7</td>
<td>4</td>
<td>5.80</td>
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<tr>
<td>Next-not-held</td>
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<td>13</td>
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<td>6</td>
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<td><strong>6 players:</strong></td>
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<td>No intelligence</td>
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<td>9</td>
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<td>9</td>
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<td>8.35</td>
</tr>
<tr>
<td>Next-not-held</td>
<td>3</td>
<td>8</td>
<td>5</td>
<td>8</td>
<td>5</td>
<td>6.69</td>
</tr>
</tbody>
</table>

Table 1. Number of turns for any player to reach a solution
The results are not exactly as predicted. Some comments regarding the predictions:

- Deal 2 took the longest to solve for the less intelligent strategies, partially fulfilling the prediction.
- Deal 5 was the fastest to solve of the other deals and deal 4 the slowest, but the differences cannot be described as marginal.

Regarding the strategies:

- The deduction strategy performed hardly any better than the no-intelligence strategy. This was despite the fact that an average of 15 deductions per player had been made by the end of Deal 2 in the 6 player game.
- The Next-Not-Held strategy seems to be the best strategy overall, and the most consistent of the intelligent strategies.
- The two strategies that focus on possible cards that other players might hold showed very variable performance, sometimes being the best strategy by far, and on other occasions performing worse than the no-intelligence strategy. Next-Possible seems to be the better of the two.

It appears that focusing on cards that other players may hold is a lottery; sometimes it leads to excellent performance, at other times it leads a player to waste turns on a red herring. It may well depend on whether the random choice picks a card that the next player actually holds; choosing one the player does not hold seems to lead to better performance. Consider the following trace for deal 5, 6 players, Next-Possible strategy:

By the time player 6’s turn comes up, he knows that player 1 has one of Miss Scarlett, the Dagger or the Hall; and one of Colonel Mustard, the Spanner or the Study. Two of these six cards are actually ‘murder cards’ (in this deal, Mrs Peacock did it with the spanner in the dining room) but player 6 decides to focus on Colonel Mustard, and is ‘rewarded’ by having player 1 show him that card.

The same thing happened on the second round – player 6 focussed on Miss Scarlett and was shown that card by player 1. By the third round of the same game (Figure 2), with no further ‘possible’ information available, player 6 has switched to focussing on the Spanner, but his query is answered by player 4 who has the Hall. On the fourth turn, player 6 focusses on the Dining Room and adds it to his previously unanswered Person and Weapon queries, and arrives at the right answer.

Some interim conclusions that can be drawn are:

- Using propositional logic about present and absent cards to guide questioning does improve performance.
- Deducing the correct room is the hardest task, so it is a good idea to focus questions on finding the room.
- Asking for cards that are known to be absent from the next player’s hand (focussing on a possible solution) is usually a better approach than asking for cards that might be in that hand (focussing on information collection).
- There are times when logical deduction makes performance worse than using no intelligence at all.

4 RELATED WORK

There have been more than one Clue/Cluedo competition where human players write their own artificially intelligent agent that competes against other agents. Hansen et al. [3] developed the Glomus server to help teach undergraduates Prolog; [4] ran a competition that simulated over 25,000 games between different agents. However, neither of these references say much about the strategies used, although [3] describes how smarter students used ‘human’ information about the less intelligent agents written by their fellow students!

There is also a Cluedo agent written in Prolog freely downloadable from GitHub [5]. However, the only ‘intelligence’ it has is in deducing what cards other players hold; it does not appear to have any question-asking strategies.

A free software Cluedo game written in C# can be downloaded from [6]. It attempts to simulate the board game closely but its note-taking pad is different; it allows marking of players who are known to have cards, and of players who are known not to have cards. There is no method provided for marking possible cards that a player may hold, nor for recording other information such as which AI players have been shown which cards from the human’s hand.

5 FUTURE WORK

There are multiple possible avenues for future work:

- Create a strategy that combines reasoning about ‘possible’ cards and ‘not held’ cards.
- Test the strategies against each other (have different players use different strategies in a single game).
• Extend the ‘intelligent’ strategies to deal with information about all other players, not just the next or previous player.
• Add probabilistic inference. If a player is asked for cards P1, W1 and R1 and shows a card, then is later asked for P2, W2 and R2 and shows a card again, it seems intuitive to assume that there is a higher probability that the player has W1 than any of the other pairs of cards. How much higher? If the player is asked for W1 a third time, how does that affect the probability?
• Introduce deductions based on ‘human’ information. This may well be the most powerful extension to the program to make it a stronger Cluedo player. The reasons are:
  ○ Correctly guessing an opponent’s strategy provides a significant extra information source; it is now possible to reason about why they chose the cards they asked about as well as about the cards they showed to other players.
  ○ Any strategy based on probabilistic inference (see above) must take opponents’ strategies into account, because there are some strategies in which an opponent will avoid showing certain cards. A statistical approach based on belief and uncertainty modelling that does not take such strategies information into account is unlikely to perform well.
  ○ It opens the possibility for using Monte Carlo simulation to hypothesize various strategies that the other players might be following and to choose the best questions to ask accordingly.
• Introduce strategies that include asking for cards that are already present in a player’s hand. This is sometimes done in the board game for misdirection but may also be done in an attempt to confirm whether one unknown card is held by any player.
• Switch from Speed Clue to Cluedo and introduce planning algorithms to move from room to room efficiently.
• Modify those planning algorithms to move other players to a player’s current location during a turn (this is part of the requesting process in the board game) not for the sake of logical deduction but to keep that player away from another location.

REFERENCES

APPENDIX

This appendix shows the full contents of each deal in the 3-player version of the game. The 6-player version splits each player’s holding in half, assigning half of player1’s holding to player4 and so on.

Master lists of cards:
Suspects: miss-scarlett mrs-peacock mrs-white col-mustard rev-green prof-plum
Weapons: revolver dagger rope lead-pipe candlestick spanner
Rooms: hall dining-room lounge billiard-room ballroom library study conservatory kitchen

Test deals for 3 player game:
Deal 1: (guilty game1 prof-plum lead-pipe hall)
(cards game1 player1 miss-scarlett col-mustard rope spanner ballroom library)
(cards game1 player2 mrs-peacock rev-green dining-room lounge study revolver)
(cards game1 player3 mrs-white dagger candlestick billiard-room conservatory kitchen)
Deal 2: (guilty game2 prof-plum spanner kitchen)
(cards game2 player1 miss-scarlett study library rope lead-pipe rev-green)
(cards game2 player2 lounge hall revolver mrs-peacock ballroom dining-room)
(cards game2 player3 col-mustard dagger billiard-room mrs-white conservatory candlestick)
Deal 3: (guilty game3 mrs-white rope ballroom)
(cards game3 player1 rev-green col-mustard revolver lead-pipe hall library)
(cards game3 player2 mrs-peacock prof-plum dining-room lounge study spanner)
(cards game3 player3 miss-scarlett dagger candlestick billiard-room conservatory kitchen)
Deal 4: (guilty game4 miss-scarlett rope kitchen)
(cards game4 player1 rev-green col-mustard revolver lead-pipe hall library)
(cards game4 player2 mrs-peacock prof-plum dining-room lounge study spanner)
(cards game4 player3 mrs-white dagger candlestick billiard-room conservatory ballroom)
Deal 5: (guilty game5 mrs-peacock spanner dining-room)
(cards game5 player1 miss-scarlett col-mustard rope lead-pipe hall library)
(cards game5 player2 rev-green prof-plum kitchen lounge study revolver)
(cards game5 player3 mrs-white dagger candlestick billiard-room conservatory ballroom)
Deal 6: (guilty game6 miss-scarlett revolver hall)
(cards game6 player1 rev-green col-mustard rope lead-pipe ballroom library)
(cards game6 player2 mrs-peacock prof-plum dining-room lounge study spanner)
(cards game6 player3 mrs-white dagger candlestick billiard-room conservatory kitchen)