

Machines are Among Us

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Abstract

The ABSTRACT is to be in fully-justified italicized text, at the top of the left-hand column, below the author and affiliation information. Use the word “Abstract” as the title, in 12-point Times, boldface type, centered relative to the column, initially capitalized. The abstract is to be in 10-point, single-spaced type. Leave two blank lines after the Abstract, then begin the main text. Look at previous CVPR abstracts to get a feel for style and length.

1. Introduction

To what extent can neural network models communicate with each other and discover each other’s identity? How would they use this information in a competitive setting? For example, in a social deduction game, players attempt to uncover each other’s hidden allegiance—typically with one “good” team and one “bad” team. Players must utilize deductive reasoning to find the truth or instead lie to keep their role hidden. In this paper, we explore if neural networks can be successfully trained to compete in a scenario such as this, and how would the opposing parties interact during the period of debate.

1.1. Among Us

Among Us is a currently popular social deduction game, where the “imposters” attempt to sabotage and kill all of the “crewmates”. Crewmates have to complete tasks and figure out who the imposters are and eliminate them before the imposters win. At certain points in the game, after periods of no direct communication, players debate the roles of each individual based on information previously acquired through their personal experience. At the end of this discussion, every player votes on a single player to be eliminated. The player with the most votes is eliminated, and if there is a tie, no one is voted out. We chose to emulate this game based on the overall simplicity of the two roles and the requirement of communication for either party to succeed. If the crew do not exchange information and all vote the same

person, the vote could result in a tie or a crew being eliminated. If the imposters do not bluff, the crew can easily spot the liars among the group. This provides ample room to explore and experiment with the communication between the two opposing parties.

1.2. Adversarial Networks

Within this design space, there are adversarial parties working against each other. In the deep learning realm, adversarial situations appear in adversarial examples [5] and within GANs (generative adversarial networks) [4]. In particular, the latter often designs a contest between two neural networks, in the form of a zero-sum game. We build upon these concepts and foundations in our work.

1.3. Multi-agent Communication

Inherently, a social deduction game requires multiple agents to be trained and contested. This has been explored within the deep learning problem space with multi-agent subproblems. Both cooperative [2] [3] and adversarial [1] communication has been experimented with, showing that models can effectively share and also selectively protect information. We reference these approaches we generate active adversarial communication between neural network models.

2. Approach

In order to examine the interactions between multiple agents – some of who are secretly imposters who must “lie”, we chose to construct an “Among Us”-esque scenario for our models to partake in. On a high level, we wanted each agent to first collect information independent of the others. Then, there should be some phase of communication between the models – qualitatively, it is during this stage that the agents will attempt to deduce who the imposters are, and the imposters will attempt to blend in. Finally, the agents all vote on who they think is a likely imposter. The upcoming sections explain how we chose to model each of these phases in greater detail.

2.1. Deductive Situation

During the period of communication in Among Us, the crew must do tasks and gain information while the imposters must sabotage and kill the crew. We decided to simplify the “game” by both removing the tasks and killing and making the entire perception of each player predetermined.

Specifically, each agent is given as input a matrix consisting of N events. During each event, the agent “sees” some subset of the other players (sight is reflexive and symmetric, but not transitive). They also may experience a “sabotage”, which means they are in the presence of an imposter who is sabotaging. They cannot see the imposter, but the imposter can see them during this event. Ultimately, each agent will receive a $N \times (P + 1)$ matrix, where P is the total number of players – the first P values of a row indicate who the agent is seeing, and the final value indicates a sabotage.

These event matrices are generated randomly using four key parameters: the total number of players (P), the number of those players who are imposters (I), the chance that any given pair of players will see one another during an event (view chance), and the chance that any given imposter will sabotage during an event (sabotage chance).

2.2. Modeling Interpretation and Communication

In order to process the input events, our agent model has an LSTM, which generates c_N and h_N , which are used as the initial inputs h_0 and c_0 to the next phase: communication. Communication is also modeled with an LSTM. During each “round” of communication, every agent contributes a message vector of size M via a small MLP using h_t as input. These messages are collected into a matrix of size $M \times P$, which is fed as input into each agent’s LSTM so that their memory can be updated before the next round of communication – there are R rounds in total. We chose to model communication this way because it is a simple and symmetric way for the agents to pass information between each other in multiple rounds.

2.3. Zero-sum Target

The last stage is the most simple one – voting. The model simply takes the h_R and c_R from the end of the communication LSTM and feeds them through a small MLP finalized with a softmax layer. This results in a probability vector of a confidence that a specific player should be “voted out”.

At the end of voting, we calculate a “crew score”. This score is simply the maximum vote-off score that any imposter received, where votes are averaged across all agents. Clearly, the imposters would like to minimize the votes on themselves, so their loss function for training purposes is simply the crew score. Inversely, the crew’s loss function is the negation of the crew score. **Zach: Relate back to GANs, zero-sum game so that adversarial works**

2.4. Training Scheme

There were multiple decisions we had to make when attempting to train the models. Imposter/Crew two different models, multitude of different hyperparameters and sizes of inputs/outputs.

2.5. Challenges

The main challenge in building and running the model came mainly in the form of training time, gradient overlap, and hyperparameter search.

Another important challenge to recognize is the extreme “black box” architecture of the model. With our current model iteration, we have no current approach to visualizing exactly what the model is doing, especially with communication. Therefore there are assumptions and estimations when creating conclusions about the model.

3. Results

3.1. Oscillating Scores

3.2. Situation Hyperparameters

3.3. Model Evolution

3.4. Interpreting Communication Vectors

3.5. Future Directions

References

- [1] Martín Abadi and David G. Andersen. Learning to protect communications with adversarial neural cryptography. *CoRR*, abs/1610.06918, 2016.
- [2] Jakob N. Foerster, Yannis M. Assael, Nando de Freitas, and Shimon Whiteson. Learning to communicate to solve riddles with deep distributed recurrent q-networks. *CoRR*, abs/1602.02672, 2016.
- [3] Jakob N. Foerster, Yannis M. Assael, Nando de Freitas, and Shimon Whiteson. Learning to communicate with deep multi-agent reinforcement learning. *CoRR*, abs/1605.06676, 2016.
- [4] Ian Goodfellow, Jean Pouget-Abadie, Mehdi Mirza, Bing Xu, David Warde-Farley, Sherjil Ozair, Aaron Courville, and Yoshua Bengio. Generative adversarial nets. In Z. Ghahramani, M. Welling, C. Cortes, N. Lawrence, and K. Q. Weinberger, editors, *Advances in Neural Information Processing Systems*, volume 27, pages 2672–2680. Curran Associates, Inc., 2014.
- [5] Ian J. Goodfellow, Jonathon Shlens, and Christian Szegedy. Explaining and harnessing adversarial examples, 2015. Published as a conference paper at ICLR 2015.

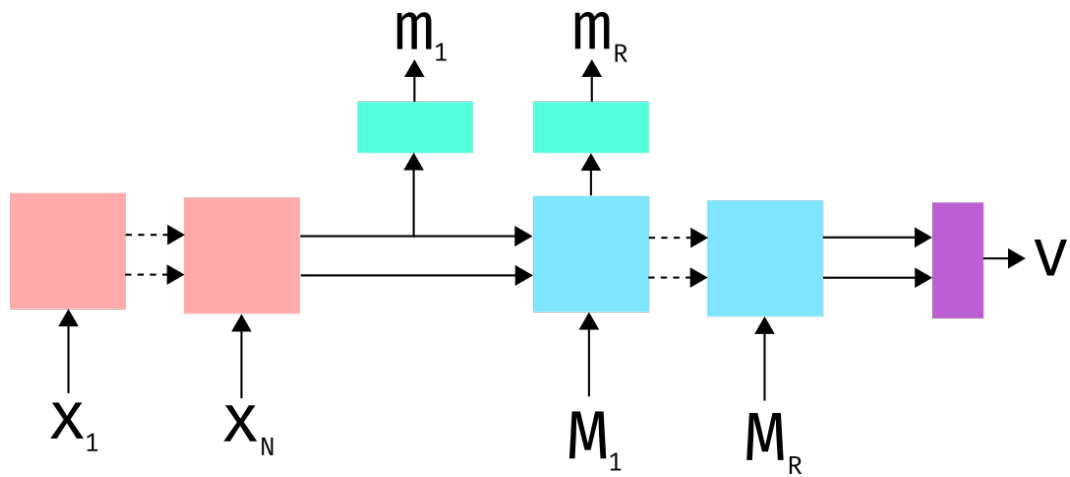


Figure 1. Diagram of the Agent model. The red section is the perception LSTM, which takes in a sequence of events. The blue section is the communication LSTM, which receives messages, and generates messages using the green MLP. Finally, the purple section is the voting MLP, which produces the agent's vote vector.