MarioAI

Social Cognitive Modelling using Artificial Intelligence

Preface

- Who? Tübingen University’s Cognitive Modeling group
  - Professor Martin Butz is the leader of research.
- Developed software to give social skills
  - Human thinking and behavior to model Mario/Luigi/Yoshi/Toad.

Article source: Butz, Martin V. "Super Mario Gets Social Intelligence." 33.2 (2016): n. pag. 2 Feb. 2016. Web. 2 Feb. 2016. <http://www.uni-tuebingen.de/uploads/media/16-02-02PM_Super_Mario_final_eng-US.pdf>.

Architecture of Algorithm

Controlled by a feedback-loop:

- Motivation System
- Reasoning
- Action Control
- Schematic knowledge

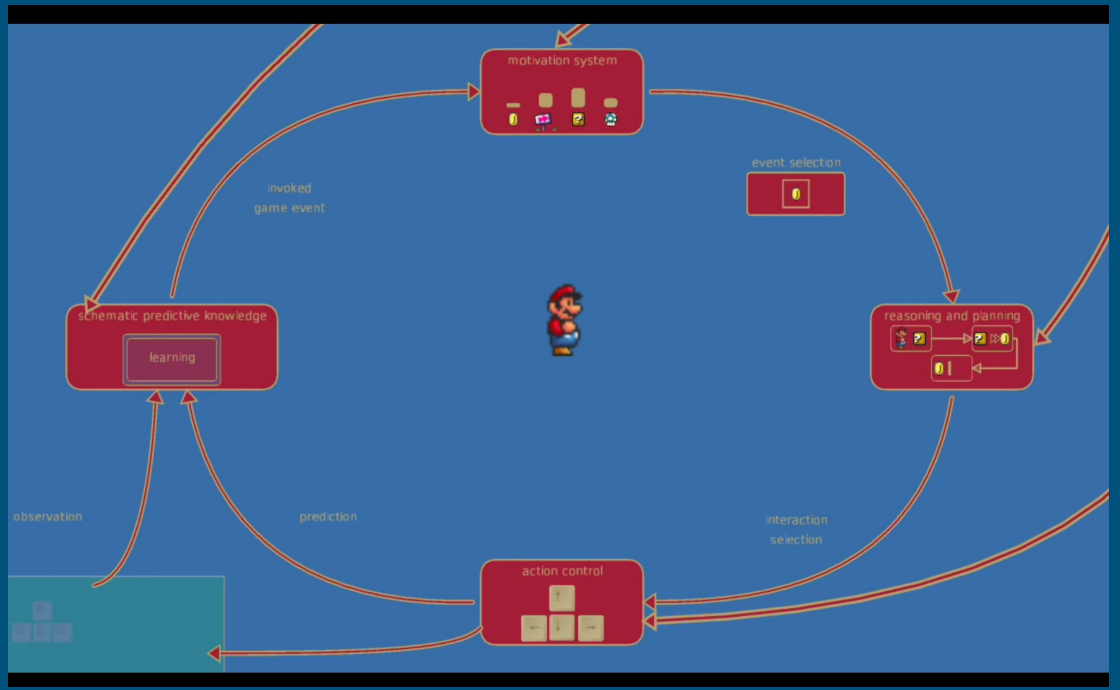

Image source: "Mario Becomes Social!" YouTube. YouTube, n.d. Web. 16 Feb. 2016. <https://www.youtube.com/watch?v=ltPj3RlN4Nw>.

Motivation System I

- The motivation system is similar to many machine learning algorithm's "Cost Function" - fitness of the character is measured numerically.
- In this case, Mario wants to:
  a. Get coins
  b. Kill goombas
  c. Finish level (Curiosity of the level)
  d. Get power-ups
- Given a set of behavior, Mario is assigned a specific "cost" for his actions. Wants cost minimized → happiness level.

Motivation System II

- How would one achieve this?
  - Answer: A machine learning algorithm such as Support Vector Machine (SVM)/Softmax classifier, Convolutional Neural Network (CNN) classifier, etc.
- Classifies next action (Press up or down?)
- Referring to a popular Neural Evolution of Augmented Topology Algorithm (NEAT)'s project about Mario (called MarI/O), has same idea.
- Neurons are hooked onto the image pixels.
- Backpropagation then used to optimize.

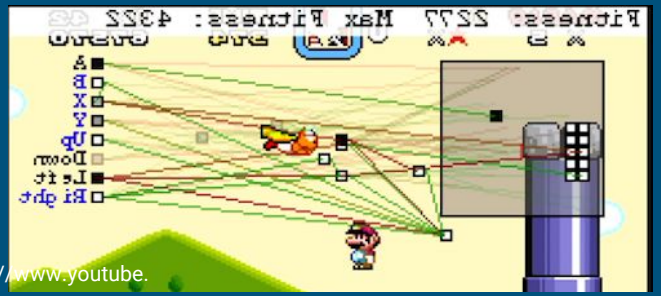

Image source: "MarI/O - Machine Learning for Video Games." YouTube. YouTube, n.d. Web. 16 Feb. 2016. <https://www.youtube.com/watch?v=qv6UVOQ0F44>.

Motivation System III

Result:

- Given current snapshot of the stage, specific neurons are reinforced for highest fitness.
- Issue: May run into local maxima(not the optimal solution)
- stuck only pressing right button.
- How do we jump past local max?
    - Excluding L-BFGS/advanced optimization

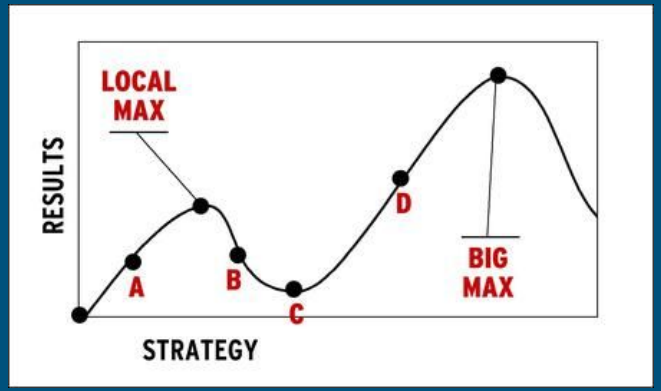

Image source: "Seth's Blog." Seth's Blog. N.p., n.d. Web. 16 Feb. 2016. <http://sethgodin.typepad.com/>

Motivation System IV

Answer(s):

- Using social interactions to:
  - change parameter, adding a neuron in the hidden layer
  - prune decision tree branches
- Situation:
  - Mario is stuck at moving to the right. Luigi might have started by jumping and breaking blocks. He will then tell Mario to jump in order to change the hyperparameters of another neural network(Mario's).

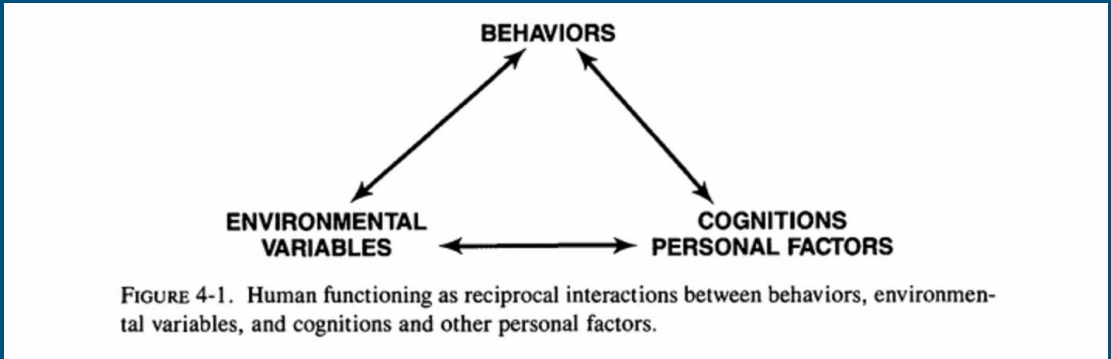

FIGURE 4-1. Human functioning as reciprocal interactions between behaviors, environmental variables, and cognitions and other personal factors.

Image source: "Social Forming Process." Image Forming Process. N.p., n.d. Web. 16 Feb. 2016. <https://explorable.com/images/social-cognitive-theory>.

Reasoning And Planning

- After the cost function been fine-tuned, the character now knows what to do.
- Transforming the inputs(image) into the outputs(button decisions), we get the predicted behavior of a “smart” MarioAI

Visualization (Schematic Knowledge)

- A vectorized implementation of this algorithm allows the prediction of action to be executed relatively quickly.
- In every frame of the game, each character goes through this pipeline.

$$Image \begin{bmatrix} X_0^0 X_1^0 X_2^0 \dots \\ X_0^1 X_1^1 X_2^1 \dots \\ X_0^2 X_1^2 X_2^2 \dots \\ X_0^3 X_1^3 X_2^3 \dots \\ \dots\dots\dots\dots \end{bmatrix} \rightarrow \begin{bmatrix} 0 \\ 0 \\ 1 \\ 0 \\ 0 \end{bmatrix} Buttons$$

Action and Control

- The feedback loop returns the one-hot-encoding matrix to the computer, and simply triggers the button for MarioAI to perform a task(press a button).
- After the action triggers, goes back into the loop.

Where does Social Interactions play a role?

- Where does the social interactions affect the characters?
  - In every stage of the game!
  - An audio and visual sensor/feedback loop for each character
- Companions receive information on how to get higher points by using each other

Is this feasible?

- In my opinion, yes, but social behavior is hard to model.
  - However, when trained, can be extremely robust (humans can teach robots)
- There’s a lot of technicalities that this research paper fails to bring up.
  - The idea of “speech” between characters is abstract and they hard-coded what appeared to be simulations of robots talking to each other(Mario and Luigi).

Is this good or bad?

- So far, not enough computational power to become a fear.
  - Factorially growing complexity
  - Social behavior modeling → AI understanding human society
- I personally believe it’s a good thing:
  - Social behavior in driving cars → same idea as Car Torrenting but utilized fully
  - Can converge faster to the local minima than most other attempts
  - AI replaces white collar jobs with social interactions (previously labor work)

What could be improved about this article?

In my opinion, they should...

- Have an actual research paper with
  - Abstract
  - Theorems provided, Method (Utilizes SVM or Neural Networks? Decision Tree pruning?)
  - Results
- Have an actual demo rather than pointless hard-coded display of what “should” happen.

Works Cited

Butz, Martin V. "Super Mario Gets Social Intelligence." 33.2 (2016): n. pag. 2 Feb. 2016. Web. 2 Feb. 2016. <http://www.uni-tuebingen.de/uploads/media/16-02-02PM_Super_Mario_final_eng-US.pdf>.

"Marl/O - Machine Learning for Video Games." *YouTube*. YouTube, n.d. Web. 16 Feb. 2016. <https://www.youtube.com/watch?v=qv6UVOQ0F44>.

"Mario Becomes Social!" *YouTube*. YouTube, n.d. Web. 16 Feb. 2016.

"Seth's Blog." *Seth's Blog*. N.p., n.d. Web. 16 Feb. 2016. <http://sethgodin.typepad.com/>.

"Social Forming Process." *Image Forming Process*. N.p., n.d. Web. 16 Feb. 2016. <https://explorable.com/images/social-cognitive-theory>.

"Welcome to the Chair of Cognitive Modeling." *Cognitive Modeling - Homepage*. N.p., n.d. Web. 16 Feb. 2016.