Long Road Ahead: Lessons Learned from the (soon to be) Longest Running Cognitive Model

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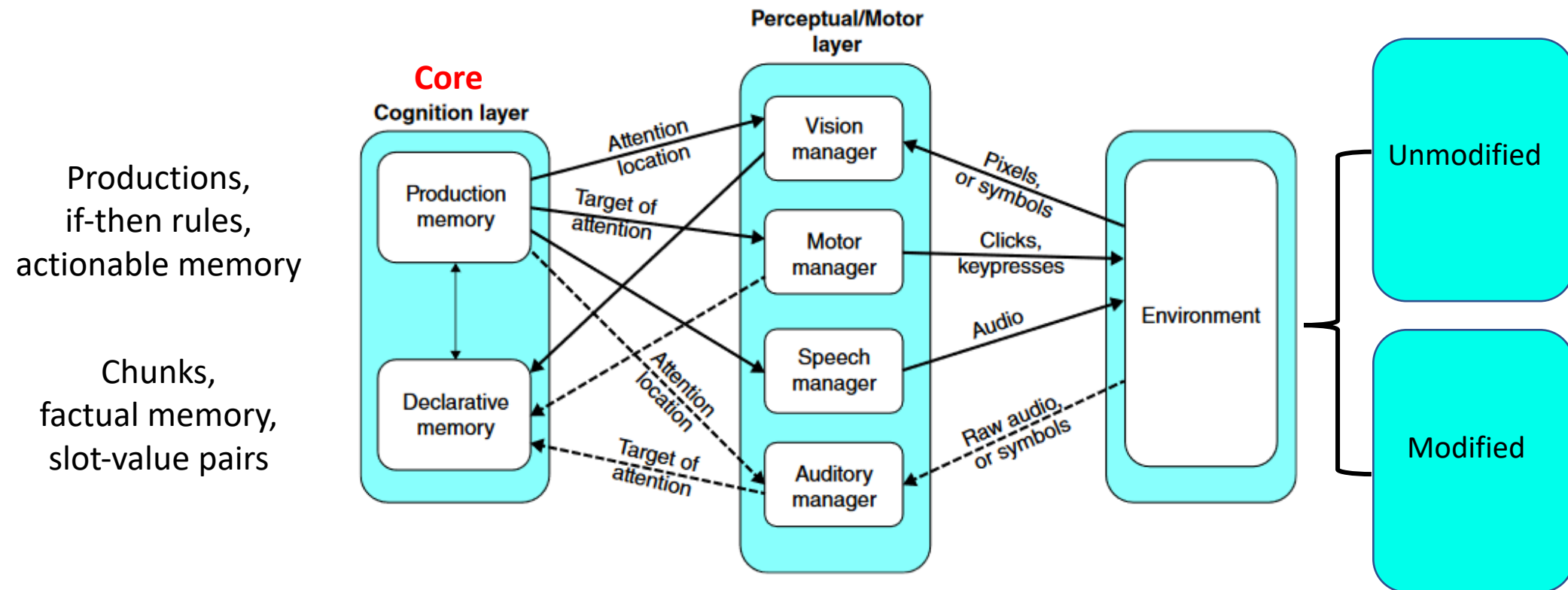
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Slides presented at ICCM 2023.

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ACT-R

- Cognitive architecture
- Modules to implement the fixed mechanisms of cognition

The Challenge with Previous Driving Simulation: Unmodified Interface

| Table 1. Limitations of the Schwartz et al. (2020) model |
| --- |
| Did not start the simulation |
| Did not drive for more than 20 min |
| Only did drive for short distance mm(s) |

Schwartz, D. M., Tehranchi, F., & Ritter, F. E. (2020). Drive the bus: Extending JSegMan to drive a virtual long-range bus. In *Proceedings of ICCM-2020-18th International Conference on Cognitive Modeling* (pp. 1-6).

We Created an Outperformed Model

- Achieved a 1200% improvement in longer driving time compared to Schwartz et al.'s (2020) bus driving model, with a maximum running time extended to 4 hours with an average running time of 1 hour

- Incorporated intelligent systems with cognitive modeling techniques (ACT-R)

- Extended capabilities with robotic hands and eyes using VisiTor

- Utilized different declarative chunks and production rules following the ADDIE framework

- Optimized the approach for creating cognitive intelligent agents

Performance Demonstration: One Loop Execution
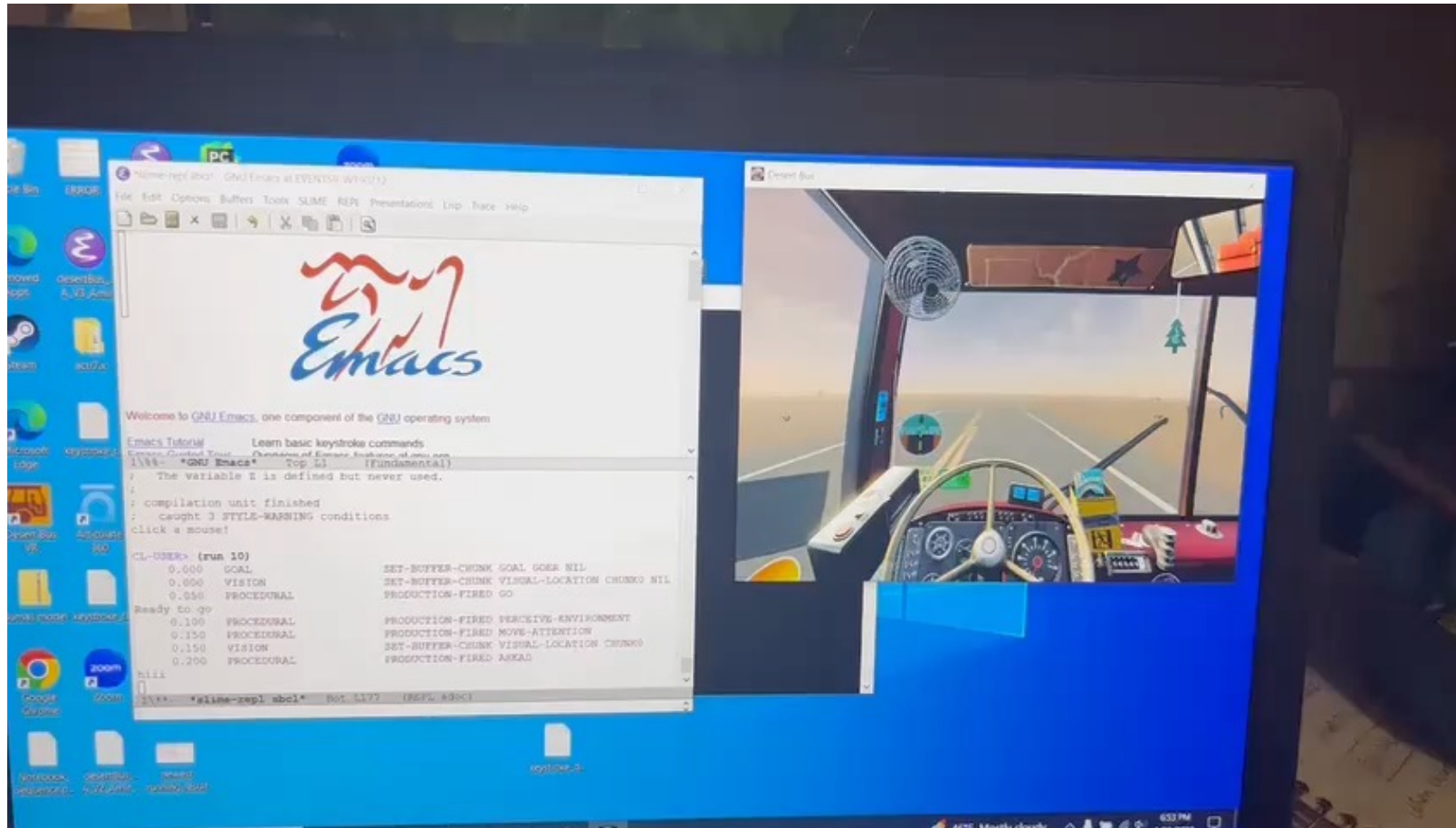
We Achieve This through the Following Enhancements

- Utilizes the ADDIE framework to replicate human driving behavior through declarative memories and production rules

- Implements a superior control mechanism to enhance long-term bus driving performance

- Enhances coordination between perceptual and motor behavior by integrating VisiTor into ACT-R 7, reducing processing time from 6.01s to 0.9s

- Leverages VisiTor's extensibility to create new functions, such as the long key press function, to improve task performance.

VisiTor

Bagherzadeh, A., & Tehranchi, F. (2022). Comparing cognitive, cognitive instance-based, and reinforcement learning models in an interactive task. *Proceedings of ICCM, The 20th International Conference on Cognitive Modeling.* 1-7.

- VisiTor is a Python software package available on GitHub that provides simulated hands and eyes for computer interactions.

- It offers two types of functions: motor functions and visual functions. Motor functions simulate mouse clicks, keypresses, and mouse movements to specific screen locations or visual patterns.

- Visual functions in VisiTor include checking for specific visual patterns on the screen, locating patterns within defined modules, and retrieving the current mouse location.

- Previous models have utilized VisiTor for interaction history, such as the "Heads and Tails" model.

Biased Coin Task

Ready

Your Choice

| Head | Tail | Reset |

Results!

Architecture of Interaction

- The model is constructed using ACT-R 7, which incorporates a Perceptual-Motor module for accessing interfaces in Macintosh Common Lisp (MCL) and refining behavior through module modifications.

- VisiTor is proposed as a solution to enable ACT-R 7 to interact with uninstrumented interfaces, providing simulated visual attention, mouse, and keyboard actions.

- In the Desert Bus task context, ACT-R directs VisiTor to scan the screen for specific patterns, initiate the program, maintain the "W" key for acceleration, and perform steering actions to keep the vehicle centered on the road.

- VisiTor underwent minor extensions to simplify object descriptions, incorporate various objects, and facilitate the transfer of motor commands with adjustable durations.

- The addition of the "longpresskey" feature in VisiTor allows for simulating customizable key-pressing actions, enabling tasks such as continuous desert bus driving.

Task

- Desert Bus

- Drive from Tucson, AZ to Las Vegas, NV

- Can go a maximum of 45 mph

- "w" to go forward, "a" to go left

- **Game runs in real-time**
 - No pausing, bus pulls right and slows down
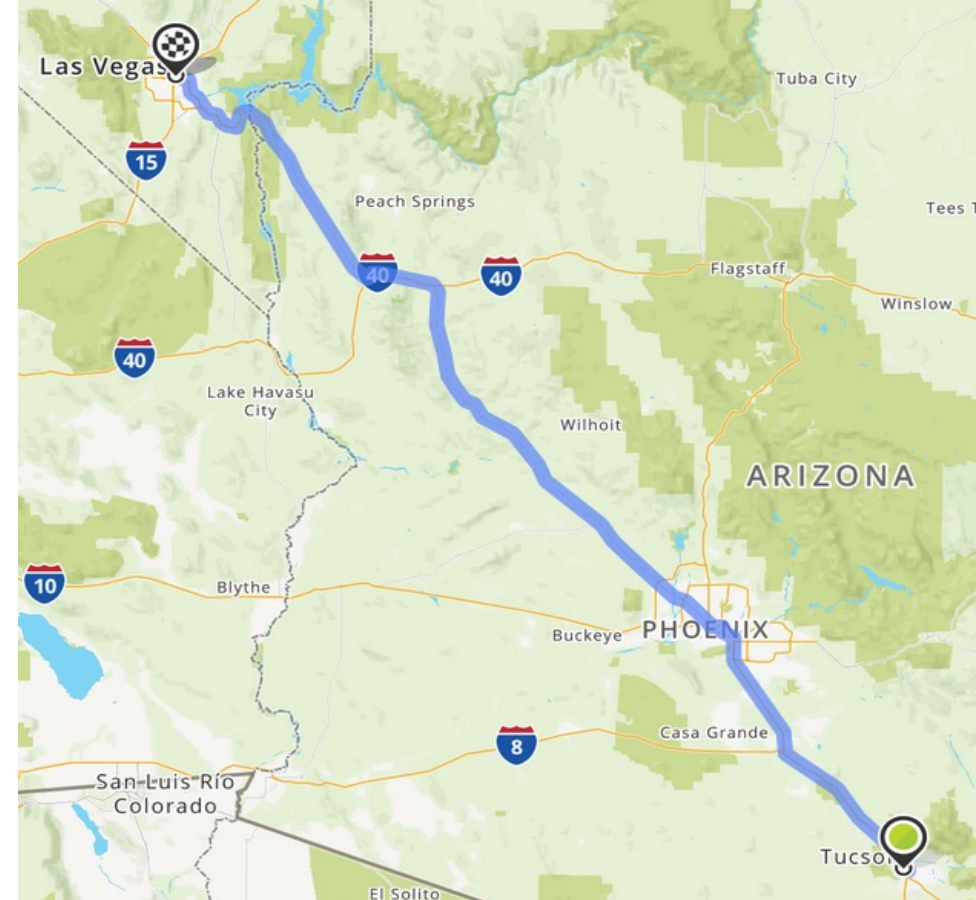
← Original

Free remake by
Dinosaur Games
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Model

- The model has two types of chunks: "drive" and "encoding", with a total of 12 declarative memories.
  - The "drive" chunk has slots for "strategy" and "state", with parameters for object items.
  - The "encoding" chunk has slots for screen-x locations of visual cues and a deviation slot.
- The model utilizes an explicit goal state to control its actions and consists of 13 production rules.
  - The model investigates the simulation environment to locate and collect the necessary visual cue to initiate gameplay
  - It uses the manual buffer to maintain forward motion by holding down the key.
  - The model continuously evaluates the environment to gather visual cues related to the bus's location.
  - It calculates the difference between the x-axis values of the center line and bus location.
  - If the difference exceeds 200 pixels, the model turns the bus left by holding down the key; otherwise, it continues moving forward.
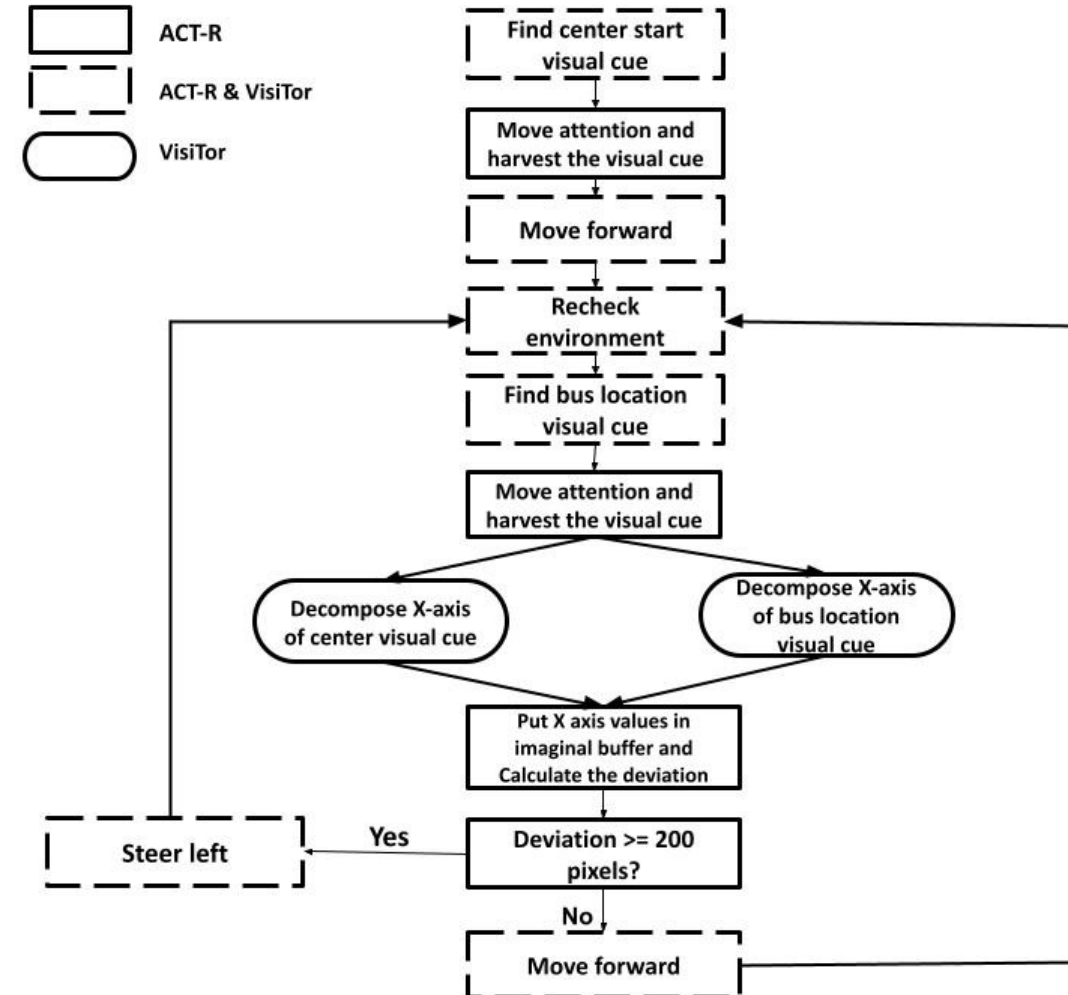
Highlights from the Simulation Results

- Model demonstrated extended running capabilities without issues.

- VisiTor's extensibility allowed for custom functions like long key presses, enhancing performance in long-term tasks, and addition of new feature in VisiTor for bus acceleration by holding "W" key.

- Model outperformed previous versions, improving accuracy and driving duration.

- Integration of VisiTor with ACT-R 7 improved perception-motor coordination, reducing visual template matching time.

- VisiTor's extensibility allowed for custom functions like long key presses, enhancing performance in long-term tasks.

Discussion

- Limitations
  - The model's performance is limited by its inability to adapt to significant environ-mental changes like the game's shift from daytime to nighttime.

- Fatigue
  - Model drives endlessly, but people cannot—what role does fatigue play?

- Motivation
  - How does a player manage trade-off of playing versus other responsibilities?

Acknowledgments