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A Novel Model of Narrative Memory for Conscious Agents

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ABSTRACT
Human mimic conscious agents, also referred to as AGI or human-like agents, emulate human cognition, encompassing perception, reasoning, and decision-making. They interact socially and act based on environment-driven choices. A conscious agent is a system that is capable of perceiving its environment, making decisions, and taking actions based on those decisions. Despite promising results these conscious agents have problem with reasoning and decision making due to not having narrative architecture as part of conscious agent. A narrative memory model for conscious agents is being developed in this research, incorporating a narrative memory module to enhance reasoning and decision-making capabilities. This model aims to simulate human-like cognitive functions, including perception, comprehension, and effective decision-making. To prove the practical application of this model, it has been implemented within a game design - a narrative-enhanced version of the game. This game shows two players' narration, allowing the conscious agents to perceive, comprehend, and make decisions based on the narration. The narrative memory module improves the agents' abilities to reason and resulting in a more sophisticated and human-like approach to decision-making within the game environment. The findings of this study could have far-reaching implications for the fields of artificial intelligence, robotics, and human-computer interaction by accelerating the creation of AGI systems with human-level cognitive capacities. In this research, new model for conscious agent having narrative memory module will be developed. So that, the model can perceive understanding and perform decision-making accordingly.

Keywords: Consciousness; conscious agents; context; narrative memory; narrative memory architecture

1. INTRODUCTION

The aim of artificial general intelligence (AGI) is to give machines brain functions similar to those of humans. Artificial general intelligence (AGI) has the cognitive abilities of a sentient being, meaning it can observe its surroundings, form opinions about them, and act accordingly [1]. Both natural and artificial systems, such as computers and robots, fall under this category. Some ideas, however, suggest that conscious entities rely on communications across distinct parts of the brain to process information from the senses, make decisions, and take action [2]. The "global workspace theory," for example, proposes that different types of sensory input are processed in different parts of the brain at the same time. This data is subsequently sent to a "global workspace" that can be accessed by other parts of the brain [3]. Conscious experiences are the result of the global workspace integrating information from working memory, long-term memory, and attention processes [4]. Consciousness, according to the "integrated information theory," arises whenever a physical system produces coherent, interconnected information. This hypothesis suggests that the more integrated information a system generates, the less self-aware it will be [5, 6]. To attempt to establish a computational model of human intelligence and consciousness, John Laird and his team developed the LIDA (Cognitive Architecture) model [7]. The concept is based on the idea of a "Global Workspace," in which information from various types of cognition is pooled and made available to all participants[8]. All computer-based simulations and models fall under the umbrella of the computational model [9]. Another example of a cognitive architecture that bridges the gap between AI and the cognitive sciences is the NIHA (Neural Intelligent Hybrid Agent) paradigm. It's a novel method that combines elements of both disciplines [10]. The term "cognitive model" is used to describe a computer or mathematical model of the processes and mechanisms that contribute to human thought. Perception, attention, memory, and decision-making are only some of the cognitive phenomena that can be simulated by these models. They're helpful for putting ideas of human thought to the test and expanding our understanding of how the mind operates [11, 12]. Understanding the human mind and creating tools and

interventions to improve performance and well-being are both made easier with the help of cognitive models [13]. Franklin and Graesser created the IDA (Intelligent Distribution Agent) in 1997 to serve as an intelligent software agent for the United States Navy. After a sailor's term of service is up, billet assignments are made [14].

Intelligent Virtual Agents (IVAs) can be constructed using the CLARION cognitive architecture. It provides a comprehensive and unified theory of mind by combining implicit and explicit knowledge representation in a hybrid architecture [15]. Top of Form ACT-R is a framework for a hybrid cognitive architecture that combines several ways of processing information. These mechanisms can be programmed to anticipate and explain human behavior, which includes both mental and environmental processes. Using task-specific information to complete assigned tasks, the proposed architecture can make predictions and offer explanations for the cognitive processes that underpin human behavior [16]. Another model of cognitive architecture created at Michigan is the State-Operator-Result (SOAR) paradigm. It is a rule-based system, therefore it follows predetermined production guidelines. Working memory, long-term memory, manufacturing, and the problem space are the four pillars of the design. To solve problems and accomplish objectives, an agent's production rules encode his or her knowledge and behavior and are applied in a top-down fashion. The SOAR model, which was developed to mimic human cognition, has been used to imitate the process of game playing, planning, and decision making, among other activities [17]. The US Air Force Research Laboratory created the ICARUS architecture to aid in the creation of smart systems that can function in highly uncertain settings. Effective system behavior is achieved through a combination of reactive control and deliberative reasoning in this hybrid approach [18].

In recent times, substantial efforts have been dedicated to the development of conscious agents, which find applications across diverse domains. These agents are designed to mirror the functioning of the human mind. However, despite their favorable outcomes, they encounter challenges in reasoning and decision-making attributed to the absence of a narrative architecture within their framework. Addressing this research gap, this research aims to construct a narrative model for conscious agents, integrating a narrative memory module. This endeavor seeks to enhance the agents' capacity for perceiving, comprehending, and subsequently making informed decisions. Multiple forms of memory are essential to the functioning of the mind and the conscious experience of sentient beings. Sensation memory, working memory, and long-term memory are the three main types of memory employed by intelligent beings [14].

In the first stage of memory recall, known as sensory memory, data is temporarily stored in preparation for later processing. It includes data from multiple senses, including sight, sound, smell, taste, and touch. The average lifespan of a sensory memory is between a few seconds and a fraction of a second. It's essential for the first stages of perceptual processing and plays a part in overall perception. Information is temporarily stored and manipulated in short-term memory, also called working memory. It can only store a few bits of data for a few seconds to a minute at a time and has a short lifespan. Reasoning, problem-solving, and decision-making all rely heavily on one's ability to store information in short-term memory [18]. The information stored in one's long-term memory can be accessed several minutes, decades, or even a lifetime later [7]. Conscious agents rely heavily on this memory system to keep track of things like their identities, past experiences, and future plans. Declarative memory and procedural memory are the two main types of long-term memory [18]. Declarative memory is the capacity to remember knowledge that can be spoken vocally; it is also known as explicit memory. Remembering particular previous events at a specific time and place is called episodic memory, while remembering facts and information regardless of time and place is called semantic memory [10]. Implicit or procedural memory is the storage of learned behaviors and routines. In most cases, no deliberate thought or effort is required. Riding a bike, typing, and playing an instrument are all examples of skills that can be stored in one's procedural memory [19].Consolidation is the process through which new memories are incorporated and established in the brain to become long-term memories. Long-term memories can be retrieved in a number of ways, including through recognition, recall, and relearning [20]. Conscious agents, such as artificial systems built to mimic human comprehension, rely heavily on narrative memory. It's crucial for things like deducing the right course of action and forming an awareness of the world around you. Self-aware beings rely heavily on narrative memory to construct their identities [21, 22]. Creating an organized and insightful account of one's life is one application of narrative memory. Conscious agents can form a sense of self and worldview through the systematic recall and analysis of their past experiences [23, 24].

2. LITERATURE REVIEW

This work facilitates autonomous human-robot interaction and is based on findings from cognitive modelling. LIDA is a systems-level cognitive model that draws inspiration from biology to explain and forecast how brains function [25]. A comprehensive overview of Soar 9.6, a cognitive architecture meant to simulate human intelligence, is provided by John E. Laird [26] Soar is an open-source project that has expanded to include numerous features and modules, such as reinforcement learning, episodic and semantic memory, and the spatial visual system. We will discuss the architecture of Soar, including its memory and processing systems, its learning modules, and the knowledge representations used by those modules, in this work. An effort has made by Arthur Juliani et al. [27] to investigate the connection between artificial intelligence and consciousness. Global Workspace Theory, Information Generation Theory, and Attention Schema Theory are only few of the functional theories of consciousness that are covered. These hypotheses emphasize the relationship of humans' conscious function and their domain-general intelligence. In their paper, "Personal Semantic Memory in Intelligent Agents," Aumm-e-haniMunir et al. [28]. This method mimics the agent's subjective thought processes by modeling their own beliefs, self-awareness, preferences, and views. Modules for sensing, learning, analyzing emotions, storing information, building one's own semantic framework, and so on are included in the model. Conversations with a chatbot, according to tests, can boost one's own semantic understanding. Rowan McAllister et al. [29] examined the issues of optimizing individual components for system-wide performance in the context of the modular structure of software for autonomous vehicles. To evaluate the knock-on effects of predictions on control, without needing the planner to be differentiable, they suggest a control-aware prediction objective (CAPO) method. D. Rudrauf et al. [30] provideed the Projective Consciousness Model (PCM) as a means of incorporating individual point of view into the mind's overall mental workspace. PCM employs projective geometric notions to construct affective and epistemic drives, implement Theory of Mind, and account for appraisal-distance correlations. In [31] this article by Deyi Li and co-authors explores the possibility that AI might possess consciousness. The basic consciousness needed for self-awareness is still absent from AI, despite its demonstrated extraordinarily high intellect. It is crucial to exercise caution when applying AI to living beings as we reach the era of artificial intelligence. John E. Laird [32] examined and contrasts ACT-R and Soar, two popular cognitive architectures used for cognitive modeling and the creation of generic AI agents. Working memory, procedural memory, and long-term declarative processing are all dissected in this study, along with their respective architecture structures, data representations, and metadata. To examine how gaming experience can be transferred from one player to another in the video game Auto Orbit, Pierre Giovanni Gianferrara, et al. [33] used the ACT-R architecture. The results show that adjusting one's timing skills is necessary for transfer between speeds and that acquiring a skill reduces behavioral variability. The cognitive architecture LIDA (Learning in a Biologically Inspired Architecture) was developed by Sean Kugele et al. [34] with inspiration from biological systems. Fundamental learning-related themes, such as LIDA's representations, the connection between its conceptual model and computational realizations, and so on, are examined, along with the restrictions of the Conscious Learning Hypothesis from Global Workspace Theory. Systems, works, Components/Elements, perceive, learn and memories-based comparison Table 1.

Table 1. Comparison of conscious agents

Conscious System	**Working system**	**Components/Elements**	**Perceive**	**Learn**	**Memories**
LIDA	Perception, attention, memory, language, and decision-making are just few of the cognitive functions that benefit from being part of a holistic cognitive architecture	Perception, Problem-solving, executive control, decision-making, emotional control, working memory, attention, and long-term memory	Consists of a perceptual hierarchy that incorporates data from several sensory modalities.	Includes a reinforcement learning method that controls how neural networks are activated.	Incorporates working memory, long-term memory, sensory and motor information into a single global workspace.

like LIDA.

NIHA	Cognitive design that simulates perception, focus, and decision-making in dynamic environments	Decision-making, perception, focus, working memory, and long-term memory emotions, self-control, and problem-solving	Models the perception of things and events as a collection of perceptual properties.	Includes a system for reinforcement learning that controls the activation of neural networks.	Components of working memory and long-term memory.
SOAR	Modeling of problem-solving, planning, and decision-making processes using cognitive architecture	Working memory, the production rule, judgment, learning, and problem-solving abilities, as well as chunking and episodic memory	Perception of models as a collection of perceptual characteristics that are integrated to create things and events	Includes a system for reinforcement learning that controls the activation of neural networks.	Components of working memory and long-term memory.
ICARUS	Cognitive architecture that simulates cognitive functions in multi-agent, complicated activities	Perception, automatic behavior, conscious behavior, three types of memory: episodic, semantic, and procedural	Models perception as a collection of aural and visual elements together to create a representation of the environment.	Combines social learning techniques, imitation learning, and reinforcement learning.	Separates the components of working memory, long-term memory, and episodic memory.
CALORIAN	Planning and reasoning-based cognitive architecture	Components of Attention, Short-Term Memory, Production Rules, Connectionist Networks, Learning, Problem-Solving, Long-Term Memory, Episodic Memory, Reflection, Self-Awareness, and Affective Processing	Objects and events are modeled as the result of a combination of a number of perceptual features.	Provides an RL approach to regulating the launch of production rules	Both declarative and procedural recollection systems.
ACT-R	models considered as a collection of production guidelines in cognitive architecture	Time, Learning, Goal Stack Conflict Resolution, Scheduling and Execution, Declarative Memory, and Production Rules	Explains perception as a system of symbols that describe the characteristics of things and occurrences	Has learning processes that combine declarative and procedural learning	Separates the components of working memory and long-term memory.

This might be because other memory systems, such as working memory and long-term declarative memory, store and retrieve more relevant information for decision-making and reasoning tasks. Despite lacking narrative

memory, these models frequently make decisions based on rule-based or procedural knowledge. However, they may be unable to reflect the entire complexity of human cognition because to the absence of a narrative memory system, which is especially important for tasks that need the integration of information across multiple events or experiences. To improve these models' abilities in this area, future research may look towards adding a dedicated narrative memory system. The findings of this study could have far-reaching implications for the fields of artificial intelligence, robotics, and human-computer interaction by accelerating the creation of AGI systems with human-level cognitive capacities. In this research, new model for conscious agent having narrative memory module will be developed. So that, the model can perceive understanding and perform decision-making accordingly. This research including conducting a thorough search for relevant papers, summarizing their key findings, and crafting a comprehensive literature review. Hence this work contributes in a way by proposing a novel model of narrative memory for cognitive agents to address the gap identified from the extensive literature review.

3. NARRATIVE MEMORY

Having a narrative memory is recalling and sequencing past experiences in a way that makes sense as a story. The ability to piece together a coherent story from fragmentary memories of the past is a key component. Understanding and conveying our experiences to others requires this type of remembering. The formation of an individual's sense of self and identity is also thought to benefit from this. Memories that are narratively remembered have been structured and organized in a story-like fashion [35]. Narrative memory relies heavily on several forms of memory, one of which is semantic memory as illustrated in Figure 1. It involves filing away and retrieving terminology, information, and ideas about the world at large. Semantic memory adds depth and texture to a story through its provision of context and background details. Narrative memory includes episodic memory as one of its main building blocks, its job is to keep track of and recall unique memories of times and locations in a person's life. Episodic memory is the basis for recalling the sequence of events and other aspects that make up a story. The narrative structure of a memory is the result of a combination of semantic and episodic memory. They help people understand and make sense of their past, which in turn allows for more meaningful and cohesive recounting of those events [35, 36].

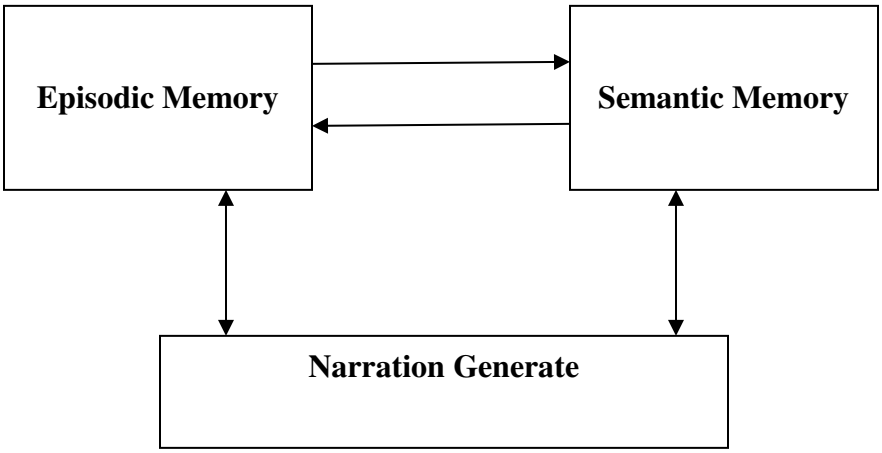


Figure1. Narration Generate

Narration relies on both episodic and semantic memory, with the relative importance of each shifting with the subject matter. Personal tales and vivid recollections of past experiences are stored in episodic memory, whereas larger context and objective facts are supplied by semantic memory.

4. PROPOSED MODEL

A novel model of narrative memory architecture for intelligent entities has been proposed. The architecture is seamlessly included into the intelligent agent, allowing it to gather and analyze data from its surroundings. Agents use a narrative memory architecture to store and recall details about their own lives. External sources, such as other agents, provide inputs that are processed by the narrative memory module and then used to create stories. It helps the model make sense of the reported content by organizing the events and experiences into a narrative structure. Episodic memory is tapped upon when one has to recollect isolated incidents that have a significant role in the story

being told. The narrative memory section of the brain is in charge of archiving details regarding the links between stories' many components, such as their characters, settings, and plots. Using semantic memory, the audience is prompted to think back on facts about the world and the characters in the story. The knowledge base is a database the model may query to produce stories, and it contains both broad, encyclopedic knowledge and specific, an individual's memories and experiences. The model's ability to construct and process narratives relies heavily on working memory, which briefly stores and manipulates information. The model uses inference to find patterns in data and draw conclusions about the order of occurrences. The model determines the story's theme, arc, and other elements based on the data provided. In the end, the model sends the generated story out to external agents who can put it to use however they see fit.

4.1. Memory

The proposed paradigm relies majorly on memory as the basis for storytelling. The model has a complete memory structure, in contrast to many other conscious agents who either lack memory components or feature just partial memory structures. The model can produce narratives and make educated decisions thanks to its comprehensive memory structure, which allows it to store and retrieve data from both working memory and long-term memory. Our model's memory structure is divided into working memory and long-term storage. Information presently being used is briefly stored and processed in working memory. Long-term memory, on the other hand, can be used to file away data for later access. Both episodic and semantic memories are sub-components of the long-term memory component. Semantic memory maintains broad, overarching information about the world, while episodic memory saves specifics about past events or experiences. Our model can generate logical stories based on a thorough knowledge of the context since it has a full memory structure. The model may then make educated choices based on the available data and its understanding of the scenario. By including full memory architecture, model can mimic the capabilities of human memory and cognition and perform at a higher cognitive level as shown in Figure 2.

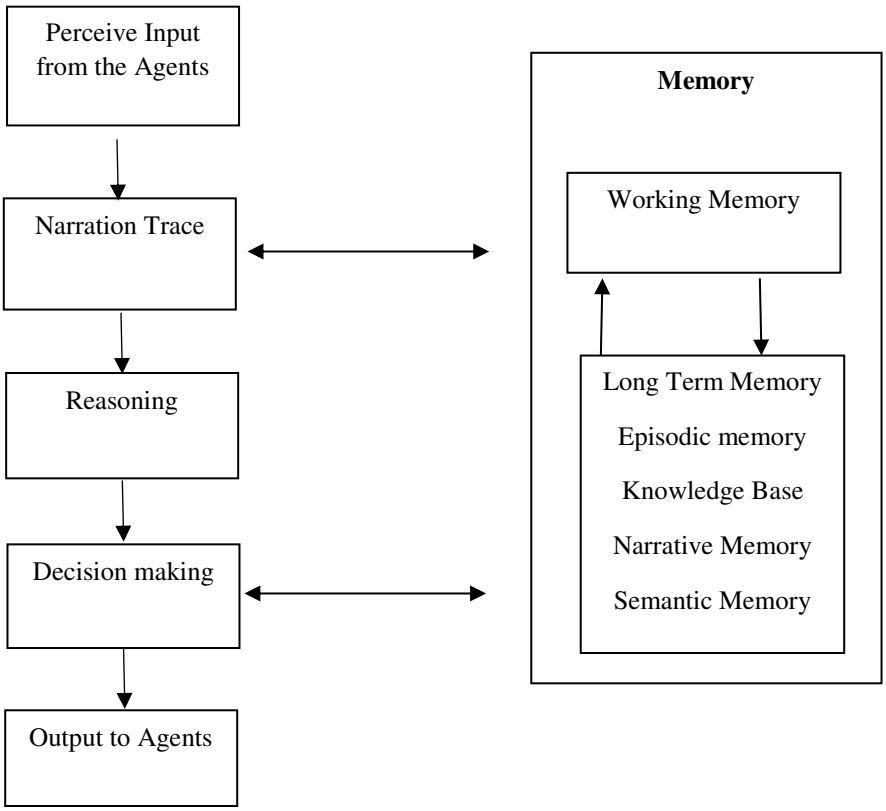


Figure 2. Narrative Memory Architecture

4.1.1. Narrative Trace Module

To make sense of all the data that has been retrieved, the model relies heavily on the Narrative Trace Module. This part of the system takes the story that was just generated and uses it to form an internal representation or memory of the things, people, and events that were specified in the input.

4.1.2. Reasoning Module

Based on the data in memory, the Reasoning Module draws inferences and makes predictions using logical reasoning and inference procedures. It takes data from the Storage subsystem and applies it to new problems, expanding the system's knowledge base.

4.1.3. Decision and Action Module

The Decision and Action Module, on the other hand, is in charge of making decisions and carrying them out based on the information stored in memory and the outcomes from the Reasoning Module. The optimum course of action is determined by using the data provided by the Reasoning Module.

5. RESULTS

5.1. Tic-tac-toe Game

The simulated tic-tac-toe game as illustrated in Figure 3, in which primary tic-tac-toe board is shown on the left side of the screen, where users can make their movements. The reading and evaluation values of the board moves are displayed in the top right corner of the screen, allowing players to make well-informed selections. Here you may find the probabilities of winning, losing, or reaching a draw after making each move. There are two players in this game, with player 1 represented by the letter X and player 2 by the letter O. This demo is meant to show off the workings of our model by showing how it interprets the narrative and gives justifications for each action taken in the game. By running these simulations, we hope to show how our model makes good use of the narrative memory architecture to record and recall the game's history in a logical and well-organized storyline. The simulations also demonstrate how the model makes use of this story to offer justifications for the players' choices, taking into account things like the likelihood of success, the likelihood of failure, and the possibility of a draw. This logic results from the model's capability to understand the setting of the game and draw on its acquired knowledge to make appropriate choices.

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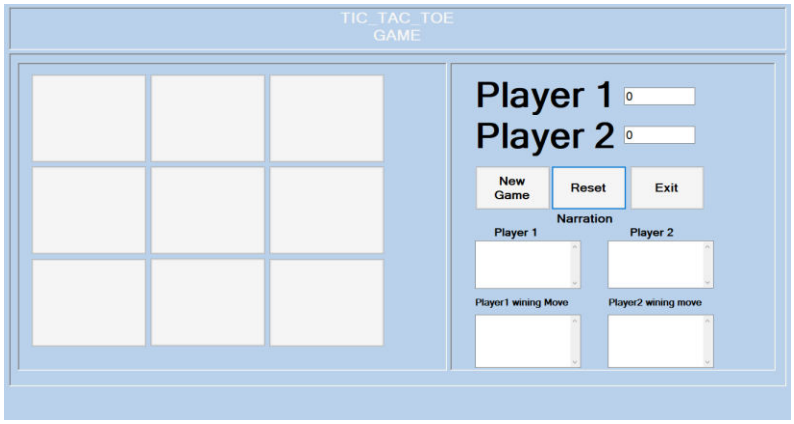


Figure 3. Simulation pf tic-tac-toe

4.2. Show Reasoning and Decision for Win Move Player-1 and Player-2

When player-1 acts, the proposed model consults its memory to find out where the game stands and make an appropriate move. The model uses this data to write a story about the game's events up to that moment. The story makes sense as a whole, detailing the actions of both players and the final state of the board. Moreover, our model uses its reasoning ability to assess player 1's move (as shown in Figure 4). Player 1's move is either a winning move, a losing move, or a move that would result in a draw, as determined by the model based on its knowledge of the game's rules and analysis of the current game state. The model's reasoning about the effects of various actions on the game as a whole is the basis for this evaluation. The ability of the proposed model to deliver meaningful feedback on the quality and significance of each action is made possible by its ability to combine narrative generation with reasoning, which greatly aids players in making educated decisions in-game.

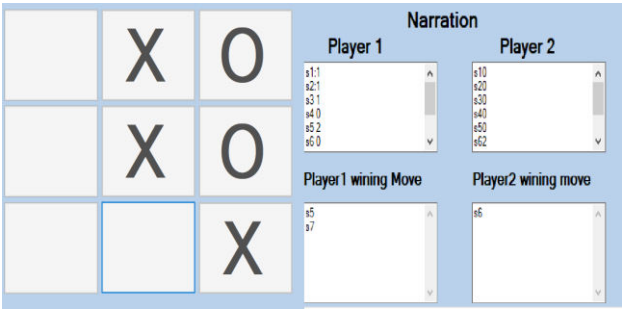


Figure 4. Player-1 Narration

4.3 Board of 3x3 Tic Tac_Toe Game

There are eight different outcomes for X on a 3x3 Tic Tac Toe board as depicted in Figure 5. Here are some ways to classify these winning permutations:

1. Row 1 (across): X1 X2 X3 (S1)
2. In the horizontal middle column we have: X4 X5 X6 (S2)
3. Bottom horizontal row: X7 X8 X9 (S3)
4. Left-hand column, vertical: X1 X4 X7 (S4)
5. Center column, vertical: X2 X5 X8 (S5)
6. Right-hand column, vertical: X3 X6 X9 (S6)
7. X3 X5 X7 (S7) reads across the diagonal from upper-right to lower-left.
8. Along the diagonal, starting at the top left, we have: X1 X5X9 (S8)

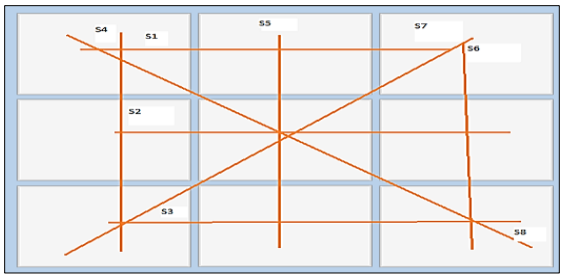


Figure 5. Player-1 and Player-2 Situation for Win

Each cell that is a part of a winning combination for X might be given a weight of 1 in order to determine the overall importance of that circumstance. A value of zero is assigned to all cells that are not part of a winning combination. The game-winning circumstances for X can be identified and prioritized with the use of this weighting. Table 2 describes the narration, reasoning and the decision for Player-1.

Table 2. Player-1

Simulation	Narration	Reasoning	Decision
Role	To justify the game's current state.	the capacity to anticipate the outcome of an action	Find out if Player 1's move won, lost, or resulted in a draw.
Task	Recall the game's current status and use that to inspire a back-story. Find the current game state in memory and make up a story to explain what has transpired so far.	Applying its knowledge of the game's rules, rate the current situation.	Use its findings to foretell the outcome of player 1's action.

Output	status of play at the moment	An analysis of the current state of the game and its rules	Determining whether Player 1's move won, lost, or resulted in a draw

4.4 Player2 win

When player 2 takes action, our model also collects the current game state and uses it to create a new story. The algorithm then uses this information to decide whether or not player 2's move was a winning one, a losing one, or a draw. This evaluation is based on a thorough examination of the game's rules and the results of Player 2's action which are shown in Figure 6.

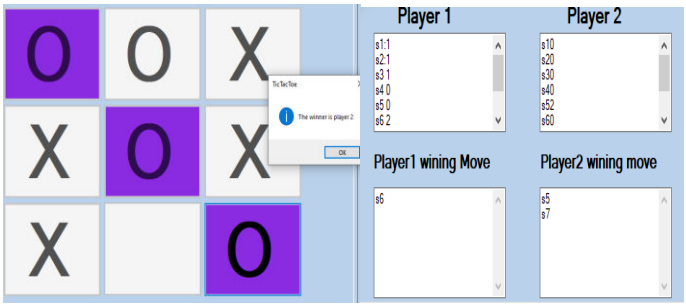


Figure 6. Player-2 Narration

There are eight possible winning combinations for O (player 2) on a 3x3 Tic Tac Toe board, the same as there are for player 1. These winning permutations can be broken down into the following classes:

1. Row 1 across the horizontal: O1 O2 O3 (S1)
2. Middle horizontal row: O4 O5 O6 (S2)
3. Bottom row horizontal: O7 O8 O9 (S3)
4. Left-hand column, uppercase O1 O4 O7 (S4)
5. In the center of the vertical: O2 O5 O8 (S5)
6. To the right in the vertical: O3 O6 O9 (S6)
7. From right to left along the diagonal: O3 O5 O7 (S7)
8. From left to right along the diagonal: O1 O5 O9 (S8)

Given that each cell contributing to a winning combination for O is given a weight of 1, and all other cells are given a weight of X, we may calculate the probability of O winning. With these parameters set, the model may isolate and prioritize O's most promising winning scenarios. Table 3 expresses the narration, reasoning and decision for the Player-2.

Table 3. Player-2

Simulation	Narration	Reasoning	Decision
Role	To justify the game's current state.	the capacity to anticipate the outcome of an action	Find out if Player 2's move won, lost, or resulted in a draw.
Task	Recall the game's current status and use that to inspire a backstory. Find the current game state in memory and make up a story to explain what has transpired so far.	Applying its knowledge of the game's rules, rate the current situation.	Use its findings to foretell the outcome of player 2's action.
Output	status of play at the moment	An analysis of the current state of the game and its rules	Determining whether Player 2's move won, lost, or resulted in a draw

6. Discussion and Limitation

The creation of conscious agents, which are AI systems or computer programs that attempt to mimic human cognition, has received a lot of attention in recent years. Robotics, digital assistants, and self-driving cars are just few of the areas where these agents are finding use. Although advancements have been achieved, conscious agents still struggle with tasks like reasoning and making decisions. The lack of a narrative structure, an essential part of human understanding, is a major contributing element. Storytelling, or "narrative architecture," is a way of structuring experiences that helps people make sense of the world and make decisions based on what they've learned. This study aim to remedy this shortcoming by presenting a novel model for intelligent agents that includes a story-based recollection system. This component will teach the agent how to take in information, make sense of it, and organize it into a coherent story that can guide its future actions. The conscious agent is expected to show enhanced reasoning and decision-making capabilities, especially in complex and unpredictable contexts, if a narrative memory module is added to the design. The agent will have a better grasp of the operational context and the ability to draw connections between events and experiences with the help of the narrative memory module.

7. CONCLUSION

In this study, we present a new narrative memory architecture for intelligent agents, with the goal of improving their capacity to take into account contextual factors while making judgments. Differentiating itself from other types of memory like semantic and episodic, this architecture makes use of a distinct memory system tailored to the processing and storage of narrative information. This design allows conscious creatures to successfully comprehend and process complicated tales by modeling human cognitive processes. When narrative memory is built into an agent's cognitive architecture, it can facilitate tasks that necessitate an awareness of context through interaction with other cognitive processes like reasoning and decision-making. These agents are able to reflect on their experiences and incorporate that knowledge into their future decisions thanks to the narrative memory system. This research is a big deal because it paves the way for more complex conscious designs for agents, which could have a wide range of uses in many different domains.

In the future, researchers will attempt to enhance narrative memory architecture for conscious beings, investigate potential new applications, and address ethical concerns related to their deployment.

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