Subsystem of Emotional Perception and Emotional Response in AGI

Abstract

The constructionist approach to the development of Strong AI presupposes structural similarity to human intelligence and a five-level structural-functional model of the human psyche—reflexes, instincts, emotions, thinking, and consciousness. This article elaborates on an approach to the algorithmic implementation of the emotional subsystem of the human psyche as a mechanism for subconscious perception of complex complexes of multimodal signals and the processing of the information received at the subconscious level for the fastest possible decision-making regarding response methods, counter-actions, and correct interaction within a social group.

Keywords

Strong Artificial Intelligence, Strong AI, Artificial General Intelligence, AGI, cognitive function of the brain, event-emotion bigraph, constructionist approach to AI modeling.

Literature Review

The scientific literature on strong artificial intelligence describes many diverse definitions of how the subsystem of emotional perception and emotional response should be constructed.

The cognitive architecture LIDA (Learning Intelligent Distribution Agent) [2], created under the leadership of Stan Franklin, combines the operation of continuous cognitive cycles with several types of learning (perceptual, declarative, procedural), allowing the agent to adapt to changing conditions of the real world.

Ron Sun developed the CLARION architecture (Connectionist Learning with Adaptive Rule Induction On-line) [3]—a well-known hybrid cognitive architecture created for modeling the human mind. The main feature of the system is the separation and interaction of explicit (symbolic) and implicit (subconscious, emotional) knowledge, as well as the combination of neural network and logical methods.

Allen Newell, John Laird, and Paul Rosenbloom [4] developed the SOAR (State, Operator And Result) cognitive architecture for general intelligence back in the 1980s, which simulated the human mind by solving any tasks through the selection of operators in a unified cycle of thinking and learning.

The technical implementation of emotions in these approaches to AGI design is based on their interpretation as high-level information signals transformed into latent space vectors. The latent space vector compresses the visual (auditory) image of an event into a vector of characteristic features.

Emotional responses are implemented using predictive coding, whereby the neural network continuously generates a prediction of the next frame/state of the world and compares it with the actual environment. If the prediction matches reality, the agent acts "on autopilot" (intuitively).

Questions of modeling and software implementation of the mechanism of human emotions are also discussed in articles [5] - [20].

Introduction

There is no doubt that the human psyche should first and foremost be considered from the standpoint of biological expediency, and the most important function of the human reactive system (which the psyche essentially is) is not only to recognize images but also to generate a forecast of the consequences of events occurring to and around a person and to develop a response to these events that minimizes potential harm and/or maximizes possible advantages.

Compared to the levels of reflexes and instincts, emotions allow for the formation of responses to complexly organized factors consisting not only of receptor signals but also including the results of processing visual (and audio) images containing information about the state and behavior of objects in the surrounding environment. An object itself may not be dangerous (or attractive); its behavior may indicate its danger (or attractiveness). A characteristic feature of emotional responses is that they can arise not only in response to the perception of a single fact but also as a result of processing a whole complex of circumstances—situations/events—and often in response to a whole chain of sequentially occurring events, and often even separated in time.

The article "Constructionist Approach to the Design of Strong AI" [1] describes the structure of the human psyche and consciousness as a multi-level system of responses to external factors. Key importance in this approach is given to mental models of external objects, phenomena, processes, etc. Responses to the processing of signals from receptors rely on previously developed and stored models of objects, phenomena, processes, and the like. These models are most useful when they are dynamic and predictive.

The levels of the response system are distinguished in accordance with the nature and significance of external factors—from the simplest (reflexes) to more complex (instincts), to even more complex and highly organized (emotions), and ultimately to the highest level (thinking).

Responses at all levels are built according to a uniform scheme:

External Factor	→	Signals from receptors to the nervous system	→	Processing of signals to recognize the external impact and select an existing response model from memory	→	Actions implementing the chosen response

Each level of perception and responses presupposes the presence, at different levels, in human memory of recognizing (biological) neural networks and previously memorized or inherited models of reactive behavior. Consciousness in [1] is interpreted as a metamodel consisting of a model of the surrounding world (with all objects and phenomena), a model of one's social group (with models of social situations and processes), and a model of oneself in this world, within this social group.

If the level of reflexes and instincts is relatively transparent, the level of emotions differs from them radically, primarily because there are significantly more models of emotional responses, they are larger, more complex, and the interconnections between them are more diverse. Emotional responses (ER) can arise not only in response to a single isolated event in a single isolated situation but also as a reaction to a fairly long chain of different events occurring at different times in different settings.

The emotional world of a person is multifaceted and complex. According to estimates from various groups of scientists, in the process of communication with other people, only 7 to 10 percent of information is extracted from the text of what is said, while 90-93 percent is transmitted and perceived through so-called "nonverbal" channels, which include facial expressions, eye movements, hand gestures, body movement plasticity, voice timbre, speech tempo, pauses in conversation, emphasis on individual words, and even the interlocutor's clothing and hairstyle, as well as the ambiance chosen for the meeting. At the emotional level, all these factors are registered subconsciously, and all of them influence the listener's attitude toward what is said and their emotional response to what they hear and what is happening.

The participation of rational perception in such aspects is most often limited to the analysis of the semantic content of the spoken phrases, which, by the way, may completely contradict all nonverbal cues. Our conscious thinking may ignore almost all of the factors listed above and draw conclusions solely based on the "text of what was said," but our intuition, very often, persistently signals to us about the insincerity of words and the "hidden agenda" in the speaker's intentions.

Human emotional responses, as a communication mechanism, formed significantly earlier than thinking and represent a complex complex of interconnected, interdependent processes in the human psyche.

It is obvious that to build a full-fledged model of strong AI, it is necessary to formulate the structure of the subsystem of emotional perception and determine the mechanism for the emergence of emotional responses.

Among the many descriptions of the structure of the subsystem of emotional perception in the human psyche leading to the emergence of ER proposed today, one of the most prominent is the theory of emotional intelligence. Daniel Goleman, in his book [5], formulated a model of emotional intelligence and identified key components:

Self-awareness (the ability to recognize one's own feelings)

Self-regulation (the skill of controlling emotions)

Empathy (the ability to understand the emotional state of others)

Social skills (the ability to find an approach to people)

Each of these components describes a certain functionality of the psyche—"recognize," "control," "understand," "find."

But "the ability to recognize one's own feelings" also implies the ability to clearly see the cause-and-effect relationship between a situation, events, and the emerging emotional response and to understand the mechanism of this perception and these responses.

Here are a few examples of cause-and-effect relationships between events and/or chains of events:

ER can arise in response to the perception of a static situation, for example:

Seeing an image of a puppy with a broken paw => ER "pity"

A laughing child => ER "laughter"

ER can arise in response to the perception of a dynamically changing situation (a chain of sequential events), for example:

A child hit their head → a grimace of pain on their face => ER "compassion, desire to help"

Difficult efforts made → successful result => ER "joy"

ER can arise in response to the perception of a series of events that occurred with different pauses between them or simultaneously, for example:

An acquaintance selflessly helped → subsequently refused a return favor => ER "friendship"

A close person promised → didn't fulfill → didn't apologize => ER "resentment"

A son prepared for a long time to enter a very good university → passed all exams → was admitted => ER "joy and pride"

A car is rushing at a person at a crosswalk → the person is walking and doesn't notice the car (two simultaneous processes) => ER "desire to help, save the pedestrian"

Perceiving a static situation requires only one visual image—an illustration.

Perceiving and responding to a dynamically changing situation requires a set of illustrations in chronological order (a series of illustrations, a slideshow-type video).
To represent a series of events that occurred with pauses between them or simultaneously/in parallel, a set of series of illustrations is required (several videos with sequential or synchronized slideshows).

All of this requires comprehension in the context of a general model of the subsystem of emotional responses of the human psyche.

Event/Emotion Bigraph

Between events, series of events, and emotional responses, there is a cause-and-effect relationship of a probabilistic nature—an ER may or may not arise, one ER or another may arise, it may be weak or strong. The same ER can arise in response to situations/events/series of events of different composition and nature, depending on the individual structure of the emotional perception subsystem of a particular person's psyche—we can laugh at both a joke and our own mistake or failure.

In the same situation, different people may have different responses—one may be angered by it, another amused, and a third left indifferent.

The connection between a situation and an ER in a particular person is determined mostly by their upbringing and environment. In established communities (stable social groups), the connections between situations and emotional responses to them are largely similar and of the same type in character but may differ in intensity. The structure of emotional perception of a particular person can be represented as an "events → ER" bigraph consisting of two graphs, where the first graph consists of nodes = events connected by cause-and-effect relationships, and the ER forms the second graph, in which nodes are emotions, and connections between these nodes arise when one emotion gives rise to new ones. Moreover, the nodes of these two graphs have cause-and-effect relationships in both directions—just as events can generate ERs, ERs can cause actions = events.

Such an event and emotion bigraph may serve as the basis for a model of the emotional subsystem of the human psyche. Mental responses at the level of emotions, no matter how complex and intricate they may seem, can be decomposed into chains of events and emotional responses that will allow, by moving backward along the arrow of time, to reach the initial response—the trigger of the entire chain. It is possible that these chains will be non-linear but branching. The study and analysis of such branching sequences becomes significantly more complicated, but their modeling based on the event/emotion bigraph remains feasible. For more efficient search in the event/ER bigraph, both the nodes and the connections between nodes in both the event graph and the emotion graph, as well as the connections between event nodes and ER nodes, should be models with their own descriptions and properties. For nodes and connections, embeddings (vectorization) need to be generated. When searching for chains of events/responses, the proximity between an event and an emotional response should naturally be estimated using the cosine distance between embeddings. This will allow automating many important tasks of processing bigraph data, such as searching for the most probable response to an event that has occurred.

Intuition

The totality of models of emotional responses developed over a person's lifetime and partially inherited from parents, as well as the ability to understand and feel the causes of chains of responses generating one another, appear to be one of the key components of what we call "emotional intelligence." Its difference from rational thinking consists in the fact that the emergence of ERs and the generation of a chain of subsequent emotions by one emotion occur at the subconscious level below the level of conscious control. The ability to foresee the development of events at the level of emotional, sensory perception, at some deep subconscious level, is very close in functionality to what we call "intuition."

Wikipedia gives the following definition of the term "intuition":

Intuition (from Late Latin *intuitio* 'contemplation', from the verb *intueor* 'to look intently') is the ability of a person to understand and penetrate the meaning of events and situations without explicit logical reasoning through a one-time unconscious inference—insight. Intuition is based on human imagination, empathy, and prior experience. In colloquial speech, intuition is sometimes called a "hunch" and insightfulness.

Google offers this definition:

Intuition is the ability to instantly find the right solution or understand the essence of a situation without the aid of conscious logical analysis. It is an "inner sense" often called the "sixth sense."

Intuition can be developed both in people with a predominantly emotional worldview—poets, writers, artists, musicians, actors, etc.—and in people with a predominantly rational-logical worldview—scientists, engineers, programmers. Emotional perception of the surrounding world always runs parallel to strictly logical, constructive perception. A scientist who has been deeply immersed in the problem of describing a new phenomenon but has not found a satisfactory explanation may experience an unexpected insight, in which the solution "emerges from the subconscious" in an already complete form, without a clear logical explanation of how it was formed. Newton's apple and Mendeleev's "dream" of the periodic table are examples of the work of those very hidden mechanisms in the subconscious that enumerate chains of causes and effects, unexpectedly exposing the necessary connections and "illuminating" the sought explanation in the form of some image, a picture in the imagination that allows one to grasp what previously could not be understood at the level of logic and to assemble it into a single rational structure.

Modeling the work of intuition, algorithmizing it, and implementing it as a neural network solution could be attempted if we take the event/emotion bigraph as a basis and estimate the probability of the next event or emotional response using cosine distance. Intuitive solutions in this case can be represented as a path in the bigraph from the initial situation to the desired one through a chain of events and associated emotional responses. Path search in a bigraph using "breadth-first traversal" is an NP-complete problem with complexity growing exponentially depending on the size of the graph. Such a solution would involve unacceptably long execution times, so it will be necessary to employ neural network tools capable of handling such tasks significantly faster, for example, an RL-based solution.
Developing an agent with such a model as its "engine," capable of building linear chains both forward and backward along the arrow of time, does not seem to be an insurmountably complex or infeasibly labor-intensive task, but rather appears quite realistic.

Undoubtedly, for situations where the events in which certain emotional responses arise form not a linear chain but a branching graph, training a neural network to predict consequences becomes a significantly more complex task. In this case, it is natural to attempt to apply the approach proposed in [1], which consists of the fact that the architecture of the agent's predictor with the required properties is not developed at once directly in code but is formed during the process of evolution, self-learning during the operation of the module implementing the corresponding genetic algorithm. The described approach will make it possible to teach a robot to "feel," endowing it with "emotional intelligence."

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