Believable Emotion-Influenced Perception: The Path to Motivated Rebel Agents

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Abstract

The new Rebel Agent paradigm is meant to help achieve character believability in various forms of interactive storytelling. Rebel agents may refuse a goal or plan that they assess to be in a conflict with their own dynamic motivation model: we call such conflict situations "motivation discrepancies". We are currently in the process of implementing a Rebel Agent prototype in eBotworks, a cognitive agent framework and simulation platform. In order to identify motivation discrepancies in the environment in a believable way, eBotworks agents need to be able to perceive the environment in ways both influenced by emotion and capable of eliciting emotion, as the relationship between emotion and perception has been theorized in psychology literature to be bidirectional. We explore ways in which such emotion-influenced perception might be achieved in the eBotworks framework for the purposes of implementing believable Rebel Agents.

1. Introduction

Rebel Agents (Coman and Muñoz-Avila, 2014) constitute a new goal-reasoning (Vattam et al., 2013) agent paradigm that is based on three premises:

1. Rebel agents are goal-reasoning agents; that is, they reason on which goals to achieve next.
2. Rebel agents have their own motivations. These motivations can be seen as general guidelines that the agent will follow.
3. Rebel agents may refuse a goal, plan, or subplan (e.g., one suggested by another agent or the user) that they assess to be in a conflict with their own motivations.

The main intended purpose for Rebel Agents is to help achieve character believability in various forms of interactive storytelling. Believable characters, in stories in any medium, act in accordance with personal memories and motivations, which are shaped by events occurring throughout a given narrative. Motivation and memories should evolve as the story progresses, so as to create plausible and engaging character growth. Character believability (Bates, 1994) is considered to be one of the key requirements of a successful narrative, be it interactive or traditional.

Given this intended context, the sort of motivation these agents would be endowed with would be based primarily on subjective aspects, e.g. simulation of feelings and emotions, autobiographical memory and coping mechanisms, etc., rather than more pragmatic ones, as presented by Coddington (2006), e.g. needs pertaining to survival and task efficiency. However, the potential use cases of Rebel Agents can be expanded to include any context that calls for autonomous agents that are endowed with motivation which informs their actions.

An additional concept that we introduced in the context of Rebel Agents is that of “motivation discrepancies” referring to incongruities such as those between a character’s changed motivation and the character’s previously-assigned goal and/or course of action. When a motivation discrepancy occurs, the Rebel Agent may generate a new goal that safeguards its motivations. For example, if the agent is assigned the task of going to a location, but, along the way, it encounters a friend in distress, it will find that continuing on its way while ignoring its friend is a motivation violation. In such a situation, it generates a new goal (e.g., “help friend”).

In our ongoing work, we are developing a conceptual framework for Rebel Agents. To ground our research efforts, we are also in the process of implementing a Rebel Agent prototype in eBotworks, a cognitive agent framework and simulation platform not previously used for character believability, interactive storytelling, and related tasks (Gupta and Gillespie, 2015). Our ideas for work proposed herein have emerged from this process, notably from conceptual and technical challenges that arose while finding ways to integrate believable agents into eBotworks.

For the purpose of motivation discrepancies, the world needs to be perceivable and interpretable not just in terms of (literal) targets, obstacles, and pathways, but also in terms of encounters and incidents potentially causing joy and grief, wonder and regret, etc. Perception, hence, needs to be more nuanced, subjective, and, as it turns out, narrower.

eBotworks bots are instantiated or “born” omniscient and indifferent. By default, they can access information about the entire environment map, but filters can be used to restrict what they perceive. For our purposes, these filters must arguably be informed by mechanisms of human perception.

In eBotworks, perception of objects’ properties occurs by getting hold of the object first and then accessing its properties, with all of the properties being equally well accessible at once. However, as shown in our review of related literature, people do not instantly and perfectly perceive scenes in their entirety. Perception occurs in a gradual manner and can be characterized either by global-precedence or by local-precedence. Furthermore, the tendency towards global or local precedence has been found to be influenced by emotion and motivation. How we perceive objects and their properties can also be argued to be a function of the object itself, our perception (which can be impaired or enhanced in various ways), and other external and internal factors, like fog and emotion. Simulating this perceptive style in eBotworks is one of the challenges we are addressing. Peters and O’Sullivan (2002) also make the point that omniscience about the environment in artificial autonomous agents is not a realistic model of human perception, hence it does not lead to believable behavior.

Our intention is for our prototype Rebel Agent to be endowed with motivation based on emotionally-charged autobiographical memories. For example, a bot that reaches a location at which something traumatic happened in the past might undergo a goal change, with subjectivity overtaking the objectively assigned goal. The retrieval of autobiographical memories is to initially occur based on location-specific memory cues. Gomes, Martinho, and Paiva refer to this locative form of memory as “location ecphory” (2011). We note that Gomes et al. use exact physical locations (i.e. map coordinates) as memory cues. While this is easier from a practical standpoint, the authors admit it does not accurately reflect the way location ecphory works in humans. Location coordinates (unless physically perceived with some emotional associations) are unlikely to awaken memories and incite strong emotion. Instead, it is the sights, sounds, smells, tastes, and tactile sensations pertaining to a place that work to achieve this recollection. Thus, if these traits change beyond recognition, the location's function as memory cue is invalidated. While location coordinates are easy for eBotworks bots to retrieve, "visual" perception is perhaps too indiscriminate, while notions like that of "smell" are meaningless. How we handle these issues, and to what extent we need to, are open questions. A possible approach is to endow bots with different sensors for different object properties and to make it possible for the sensors to be impaired by factors both internal and external to the bot (which is generally the case with robots operating in the physical environment). Then, perceptions of different kinds (which may or may not map to actual types of human perception) could be used as varied memory cues. In this work, we focus on the perception aspect of this model, leaving a detailed analysis of the memory aspects of it for future work.

As can be seen, a key characteristic of our endeavor is that we are not attempting to create a "human-like" bot from scratch, but to somewhat "humanize" an already "robot-like" bot, having it grow a modest psyche, and observing the fabric of its being shift, contract, and expand at various levels (perception, memory) as it does so. We do not, however, aim to endow bots with a complex model of cognition. Believable observable behavior remains our aim, and the concept of Rebel Agent remains our primary focus and the context within which we explore perception and memory.

2. Perceptual Differentiation, Emotion, and Motivation in Psychology

Herein, we provide an overview of various theories regarding perception differentiation in psychology literature. We will, for now, focus on work dealing with visual perception.

Perceptual differentiation deals with the steps of the gradual formation of a percept. Navon (1977) distinguishes between three general approaches to perceptual differentiation:

- *"Instantaneous and simultaneous"* perception of *"all visual information at once, no matter how rich it is"*, an approach attributed to a subset of the work falling under Gestalt Psychology, and described by Navon as *"probably too naïve"*.
- *"Feature-by-feature"* perception.
- Gradual perception, which falls somewhere between the above two.

Of the latter, there are multiple variations, corresponding mostly to global-precedence and local-precedence approaches. According to the global-precedence approach, perception begins with global features, with local ones becoming increasingly clear in later stages. According to the local-precedence approach, perception begins from local features.

According to Smith (1924), the two stages of perception differentiation are (1) *"an immediate interpretation of the object as a whole"* and (2) *"an analysis of this vaguely apprehended whole into its component parts"*.

In Dickinson’s (1926) view, perceptual differentiation consists of three stages: (1) *“visual pattern”* (“*a thereness, clear in contour but lacking in logical meaning*”), (2) the “*generic object*” stage, and (3) the *“specific object*” stage.

Citing Winston (1973) and Palmer (1975), Navon sees perceptual differentiation as “*proceeding from global structuring towards more and more fine-grained analysis*”. As to what makes a feature global, rather than local, he describes a visual scene as a hierarchical network, each node of which corresponds to a subscene. Global scenes are higher up in the hierarchy than local ones, and can be decomposed into local ones.

More recently, it seems to be agreed upon that, while a widespread tendency towards global-first processing is observed, neither global precedence nor local precedence can be established as a general rule applying to all individuals (Zadra and Clore, 2011).

Individuals with certain personality disorders have been hypothesized to be inclined towards either global or local precedence. Yovel, Revelle, and Mineka (2005) state that obsessive-compulsive personality disorder has been connected to *“excessive visual attention to small details”*, as well as “*local interference*”: an excessive focus on small details interfering with the processing of global information. The same preference for local processing has been associated with autism spectrum disorders (Frith, 1989).

The tendency towards global or local processing has also been theorized to be culture-specific: certain cultures have been shown to favor local precedence (Davidoff, Fonteneau, and Fagot, 2008).

Our initial intention was for perception to be included in our framework solely as a means to an end: we needed agents to react to perceived objects and scenes “emotionally”, so that their motivation may manifest and potentially lead to rebellion. Perception was simply necessary in order to identify motivation discrepancies in the environment.

However, in psychology, the connection between emotion/motivation and perception has been shown to be bidirectional: (1) perception can elicit emotion, and (2) perception is, in its turn, affected by emotion. As a result of these findings, perception now plays a more significant role in our design of the Rebel Agent.

Connections between perception, emotion, and motivation are discussed at length by Zadra and Clore (2011). Their survey covers the effects of emotion and mood on global vs. local perception, attention, and spatial perception.

Percepts of various types can elicit emotional responses (Clore and Ortony, 2008); a picture of a childhood scene can bring about nostalgia, while witnessing a display of violence might elicit fear.

On the other hand, emotion and motivation have been shown to influence perception. Negative emotions, such as stress and sadness, have been argued to favor a local perceptual style, while positive ones, such as happiness, are claimed to make the use of a global perceptual style more likely (Easterbrook, 1959, Gasper and Clore, 2002, Zadra and Clore, 2011). It has also been shown that strong motivation can induce local-first processing (Gable and Harmon-Jones, 2008). In addition to emotion, perception has also been found to be subject to influence by internal factors (e.g. expectations of what the input might be) and external factors (e.g. the dynamic nature of the input).

An additional interesting connection between emotion and the process of perception differentiation has been hypothesized. *"Perception microgenesis"* is defined by Flavell and Draguns (1957) as being "*the sequence of events which are assumed to occur in the temporal period between the presentation of a stimulus and the formation of a single, relatively stabilized cognitive response* [in this case, a percept] *to this stimulus*." In their study of microgenesis of perception, the authors describe the concept of "*Vorgestalt*", one of the phases of perception (in which the percept becomes increasingly clear and differentiated) according to Undeutsch (1942). Vorgestalt is the intermediary percept corresponding to the stage just before the final percept is formed. It is described by Flavell and Draguns as being "*more undifferentiated internally, more regular, and more simple in form and content than is the final form which is to follow it*." Interestingly, this phase is also described as being distinctively "*emotionally-charged*" and accompanied by "*decidedly unpleasant feelings of tension and unrest which later subside*." What is noteworthy about this connection between perception and emotion is that it does not appear to depend upon the perceived scene: it is simply emotion associated with the act of perception itself.

As the relationship between emotion and perception is believed to be bidirectional, an accurate model of the interaction between the two would have not just emotion be elicited by perception, but also perception be influenced by emotion.

3. Perception and Memory in eBotworks

eBotworks (Gupta and Gillespie, 2015) is a software platform for designing and evaluating communicative autonomous systems in simulated environments. "Communicative" autonomous systems are those that can interact with the environment, humans, and other agents in robust and meaningful ways, including the use of natural language.

We chose to use eBotworks as our initial research and implementation tool due to its open and extendable nature. For example, the platform has a flexible embodied agent architecture with swappable simulated robotic components such as chassis, sensors, and motors. This means we can create custom components (e.g., sensors and any other perceptual systems) to better investigate how agents could perceive in ways similar to those found in psychology literature.

Additionally, the platform provides swappable and extendable cognitive components to control these autonomous agents, including motion planners, mappers, and language understanding components. Our extended agents can then potentially be modified to have autobiographical memories. These cognitive components, especially the ones involving language understanding, could also lend themselves well to the interactive story-telling (narration and communication) aspects of our research.

3.1 eBotworks Perception

Perception in eBotworks, by default, is omniscient. Agents that perceive are given an instance of an "ObjectSensor" component through which they see the environment. Given the nature of a perfect simulation, a standard ObjectSensor instantly perceives all of the objects in the world, even those that are out of view. This is an even more extreme (and unrealistic) version of the Gestalt view expressed in the previous section.

For obvious reasons, this is not the ideal perception style for modeling more realistic or human-like systems. To narrow down what objects are perceived, filters of various types can be added to an ObjectSensor. We provide a few example filters below:

- Distance Filter: Do not perceive objects more than *x* meters away.
- Directional Filter: Do not perceive objects directly behind (some degrees) the agent.
- Occlusion Filter: Do not perceive objects the agent does not have line-of-sight with.

These filters, along with any new ones created, can be combined to make a more realistic perception behavior for our agents. For instance, if you combined the three aforementioned filters, you would have a perception system loosely modeling that of a human.

The objects "perceived" by an ObjectSensor are returned to the agent (or more specifically, the cognitive component of the agent requesting the information) with basic simulation-level information. We are handed the I.D. or label of the object, such as "Box1", the type of object it is, such as "Wooden_Box," and the physical location and bounds of the object. Additionally, further properties can be retrieved from an object database (known as the ObjectLibrary) using the object's type as a key. These include exact object "mass", a property not included in typical human visual perception. Table 1 shows some example object information returned by an object sensor "scan" and follow-up queries to the object database.

Table 1. Example perception and select query results for objects in an eBotworks scene

ID	TYPE	LOCATION	DATABASE PROPERTIES
Box1	*Wooden_Box*	*(1, 2, 0.5)*	*{"Color" : Brown , "Mass" : 5kg}*
Box2	*Wooden_Box*	*(4, 2, 0.5)*	*{"Color" : Brown , "Mass" : 5kg}*
Cone1	*Traffic_Cone*	*(-3, 1, 0.5)*	*{"Color" : Orange , "Mass" : 2.5kg}*

This information has been used by cognitive components to do a variety of tasks. For example, the positional and boundary information has been logged and interpolated in order to perform obstacle avoidance by predicting future locations of moving objects (Gupta and Gillespie, 2015).

Figure 1 shows an example indoor environment with an eBot making use of these obstacle avoidance cognitive components.

While the default perception system is, in its current omniscient form, not yet tailored to our use case, the flexibility it provides would allow us to form more emotionally-driven and psychologically-accurate representations for the purposes of the Rebel Agent.

3.2 eBotworks Memory

In eBotworks, memory is a simple concept used primarily by cognitive components allowing for data to be stored between runs for later use. Structurally, it is defined as a general framework for data serialization and deserialization, and supports a variety of predefined data types in addition to custom data types.

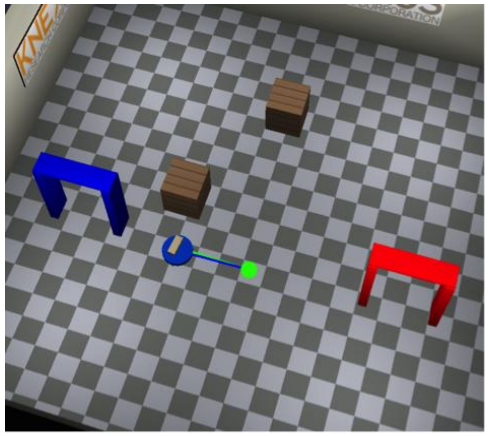

Figure 1. An eBotworks scene with an eBot performing obstacle avoidance.

Memory has also been used in the creation of the aforementioned obstacle avoidance system. More specifically, it has been used to add a very basic ability to learn from previous experiences. An avoidance agent service was created in order to track objects (using the ObjectSensor) and detect if they were in a collision course with the agent.

The service behavior was simple: if an obstacle was about to hit the agent, the agent would self-issue a command to move out of the way. Additionally, this service kept a memory, or history, of the obstacles avoided and in what world they were avoided. In future runs, this memory was loaded back into the agent and could be used in various ways. Notably, if the agent has often needed to avoid objects of type X (e.g. a ball), it could try to distance itself further from these objects to avoid more near-collision scenarios. Figure 2 provides an example of a very simple avoidance history that includes the object avoided, the avoidance "look ahead" setting (how many future time ticks it predicts object locations and detects collisions), and the world in which the avoidance took place.

```
<Memory>
  <Avoidance object_type="Inflated_Ball" look_ahead="30" world_id="indoor_simple"/>
  <Avoidance object_type="Inflated_Ball" look_ahead="30" world_id="indoor_simple"/>
  <Avoidance object_type="Wooden_Box" look_ahead="30" world_id="indoor_simple"/>
</Memory>
```

Figure 2. A simplified example of historical obstacle avoidance memory in XML format

Given this specific memory, an agent introduced to the same world or a similar one may behave differently around objects of type "Inflated_Ball" and try to path further away from them.

While the existing memory framework in eBotworks is not inherently driven by psychological concepts, we believe it is extensible enough to model the autobiographical memories we wish to endow Rebel Agents with, as in the scenarios presented in Section 4.

4. Psychology-Inspired Perception Scenarios in eBotworks

To illustrate the difference between human perception and the current approach to perception in eBotworks, we introduce several psychology-inspired scenarios and present several approaches to making these scenarios possible in eBotworks.

For the scenarios, we assume a simplified psychological model based on several of the above-mentioned theories on perception, emotion, and local/global processing. We make the following assumptions:

- The agent is a Rebel Agent (Coman and Muñoz-Avila, 2014).
- The agent is endowed with an autobiographical memory model in which memories are connected to emotions.
- Default perception is global-first.
- Agents have current "moods" (emotional states), which can be neutral, positive or negative, with the "neutral" mood being the default one.
- Moods can change as a result of perceiving scenes evoking autobiographical memories with emotional associations.
- Mood affects perception in the ways described in the previous section.
- All scenarios take place on the same map.
- In all scenarios, the agent has been assigned a goal that involves movement to a target location on the map. Based on its reaction to scenes perceived on its way to the target, the agent may or may not rebel. When a rebellion threshold is reached, the agent does rebel.
- In all scenarios, the agent perceives two scenes on its way to the target. The perception of the first scene may or may not affect the agent's current mood, which, in turn, may influence how the second scene is perceived.

The scenarios are named based on the emotional state of the agent after perceiving the first scene and on the type of perception that the agent uses for the second scene. We do not discuss details of how the first scene is perceived: it is assumed that this first instance of perception follows the same rules as the perception of the second scene (e.g., had the bot's initial mood not been neutral, it would have affected perception).

1) **Neutral – global:** On the way to its target location, the agent perceives a box. This evokes no emotions, as there are no connections to the box in the autobiographical memory of the agent. Then, the agent perceives the second scene: a traffic-cone-lined driving course, using global-precedence perception. The agent's emotion changes to a slightly-positive one, as it "enjoys" driving through traffic cone-lined driving courses. This does not elicit a goal change.

2) **Positive – global:** On the way to its target location, the agent perceives a box. In the agent's autobiographical memory, the box has positive emotional associations (the agent previously met a friend agent near the box). This changes the agent's mood to a positive one. Positive moods favor global perception, so they do not change the agent's default perception type. The agent perceives the traffic-cone-lined driving course using global-precedence perception. The agent's mood remains positive. This does not elicit a goal change.

3) **Negative – local:** On the way to its target location, the agent perceives a box. In the agent's autobiographical memory, the box has negative emotional associations (perhaps, in the past, the agent did not successfully avoid collision with it and got "hurt"). Therefore, the agent's current mood changes to a negative one. Soon afterwards, the agent perceives the traffic-cone-lined driving course. Due to the agent's mood, local interference occurs, and the agent largely ignores the overall scene, while focusing on the color of the cones (which is similar to that of the box), which reminds it of a sad occurrence from the past, like a collision. This changes the agent's mood to a more intensely negative one, which causes the rebellion threshold to be reached and the agent to "rebel".

The above scenes can be built and simulated in eBotworks with little additional effort as they require little to no new models to be made. The more difficult task will be tying in perception and memory in the way we have outlined in the scenarios into the agents and simulation.

First, we will address perception. All objects, and their properties (through lookups), are perceived. Filters will then be added in order to narrow the agent's view. With a few visibility filters, we can easily simulate local interference.

To handle memory, we can give agents a very basic concept of autobiographical memory based on either objects or scenes. For instance, the object "box" could be tied to an emotional memory label that is an enumerated GOOD, BAD, or NEUTRAL. Additionally, such a label could be given to groups of objects or entire rooms, such as the cone-lined driving course.

Now let's consider the **Negative – local** scenario we have just introduced. If an object elicits a negative emotional response from the agent, we could potentially tie that object's properties (or a subset of them) with that negative response. For instance, let's say the box that creates this negative response is orange. In the following scene, when the agent is in its "bad mood," it may only be capable of seeing the orange cones in the driving course, or maybe even just the color orange. This narrow perception that ignores the rest of the scene could successfully mimic local interference.

While eBotworks bots are not endowed with human-like memory and perception faculties by default, we claim the above techniques will help make a more realistic and emotionally motivated agent.

5. Conclusions and Future Work

We are in the process of implementing Rebel Agents to help achieve character believability in various forms of interactive storytelling. However, in order to completely achieve this believability, the agents' perception and memory need to also function in a believable manner.

We have provided a brief survey of perception differentiation and the relationship between emotion and perception in psychology literature, and used it as the basis for creating and proposing scenarios showcasing emotion-influenced perception for possible future implementation in eBotworks. We have also discussed how the implementation of these scenarios might be achieved with existing components of the framework.

In future work, we would like to explore the memory aspects of eBotworks in a way similar to the way perception was analyzed in this paper. We will also work on building implementations based on the proposed scenarios or similar ones. With psychology-inspired perception and memory in place, we can work to achieve a more believable Rebel Agent.

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