Case-based Local and Global Percept Processing for Rebel Agents

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Abstract. Rebel Agents are goal-reasoning agents capable of “refusing” a user-given goal, plan, or subplan that conflicts with the agent’s own internal motivation. Rebel Agents are intended to enhance character believability, a key aspect of creating engaging narratives in any medium, among other possible uses. We propose to implement and expand upon a Rebel Agent prototype in eBotworks, a cognitive agent framework and simulation platform. To do so, we will make use of (1) a case-based reasoning approach to motivation-discrepancy-perception, and (2) user input for creating the agents’ “emotional baggage” potentially sparking “rebellion”.

Keywords: rebel agents, character believability, local and global perceptual processing

1 Introduction

Rebel Agents [6] are motivated, goal-reasoning agents capable of “refusing” a goal, plan, or subplan assigned by a human user or by another agent. This rejection is the result of a conflict arising between the given goal or plan and the agent’s own internal motivation. In our previous work, we made the assumption that this motivation is modeled for the purpose of creating character believability [1], a key aspect of engaging narratives in any medium. However, different motivation models are also applicable. In the context of rebel agents, the term “motivation discrepancies” refers to incongruities between a character’s motivation and the character’s assigned goal and/or course of action. When a motivation discrepancy occurs, depending on the perceived intensity of the incongruity, the Rebel Agent may generate a new goal that safeguards its motivations. While so far explored in the context of interactive storytelling and character believability, the potential applications of rebel agents are by no means limited to this. Such agents can also be useful, for example, in mixed-initiative situations in which the Rebel Agent may have access to information unavailable to its human collaborator, and use this information to decide when to reject a command received from the collaborator.

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We are in the process of developing a conceptual framework for Rebel Agents and implementing a Rebel Agent prototype in eBotworks, a cognitive agent framework and simulation platform [15].

In previous work [7], we explained that, for the purpose of detecting and reacting to "motivation discrepancies", eBotworks agents should be made able to perceive and interpret their surroundings in "subjective" ways potentially eliciting "emotion" intense enough to cause rebellion. We showed how eBotworks agent perception, which is by default omniscient and objective, needs to be modified to more closely mimic (or appear to mimic) human perception. We also described that this can be achieved using sensory filters informed by mechanisms of human perception. These mechanisms include gradual perception differentiation, local and global percept processing and, perhaps most importantly for our purposes, the bidirectional connection between perception and emotion. That is, perception can elicit emotion and is, in turn, affected by emotion.

While relying on psychology literature to build these filters, we are ultimately aiming for agents with believable observable behavior, but not based on complex models of cognition.

We aim to endow our prototype Rebel Agent 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 appropriate to the context. The retrieval of autobiographical memories is to initially occur based on location ecphory [14], that is, location-specific memory cues. They use exact physical locations (i.e. map coordinates) as memory cues. This choice is preferable from a practical standpoint, but does not accurately reflect the way location ecphory works in humans. The characteristics of a location that awaken memories and incite emotion tend to be the sights, sounds, smells, tastes, and tactile sensations pertaining to it, not necessarily its map coordinates. However, while location coordinates are easy to retrieve and to compare, the same cannot be said about complex combinations of percepts.

In previous work [7], we explained how the perception mechanisms of eBotworks can be modified in order to acquire percepts in a more "human-like" manner.

Herein, we approach the challenge of retrieving past percepts and comparing them to current ones using the case-based reasoning model, which is a natural match for this retrieval process. Case-based reasoning literature offers examples of complex case structures and associated similarity measures (e.g., [4][13][18]), allowing us to store and compare complex scene representations, thus taking location ecphory beyond mere map coordinates.

In building a case base consisting of "memories" of percepts and associated emotions, one of the challenges is providing the basis upon which the agents associate emotions to percepts. While this could be accomplished by building a complex inner model of the agent, herein, we discuss a knowledge-engineering-light alternative. This new approach could leverage the chat-based interface of eBotworks, through which users can give agents commands. In our context, human users would be directing the agent how to "feel" in certain situations. That way, the agent, instead of being provided with a complex program dictating how it should behave in various contexts, picks up an "emotional baggage" derived from that human user's personality (or just a "role" that the human user chooses to play). By getting input from different human users, we can produce a range of bots roughly exemplifying various personalities.

Our two contributions herein are:

(1) Exploring a case-based reasoning context for motivation-discrepancy-perception in eBotworks Rebel Agents.
(2) Proposing the use of chat-based user input for creating the agents' "emotional baggage", potentially sparking "rebellion".

Finally, it must be mentioned that, although we approach them in this specific context, local and global percept processing are applicable not only to Rebel Agents, but to any intelligent agents endowed with perception capabilities.

2 Local and Global Percept-Processing and Emotion

Gradual perception differentiation and local and global percept processing have been shown, in psychology literature, to characterize human perception. Human perception has also been shown to stand in bidirectional connection with emotion; percepts of various types can elicit emotional responses [5], while perception can be influenced by emotion and motivation as explained below [9][12][22].

Perception differentiation deals with the steps of the gradual formation of a percept.

Global-first percept processing begins with global features, with local ones becoming increasingly clear in later stages. It has been argued to be induced by positive emotions, such as happiness. Citing [17] and [20], Navon [16] sees perceptual differentiation as always "*proceeding from global structuring towards more and more fine-grained analysis*". As to what makes a feature global, rather than local, Navon 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, it cannot be established as a general rule applying to all individuals at all times [22].

Local-first percept processing begins from or focuses on local features. It has been argued to be more likely when under the influence of negative emotions, such as stress and sadness. However, strong motivation has also been shown to be capable of inducing local-first processing [11]. Individuals with certain personality disorders have been hypothesized to be inclined towards local precedence. Yovel, Revelle, and Mineka [21] 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 [10].

The tendency towards global or local processing has also been theorized to be culture-specific: certain cultures have been shown to favor local precedence [8].

Connections between perception, emotion, and motivation are discussed at length by Zadra and Clore [22]. Their survey covers the effects of emotion and mood on global vs. local perception, attention, and spatial perception.

3 Local and Global Percept Processing for Rebel Agents in eBot-Works

eBotworks [15] 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. eBotworks tasks have so far been limited to path-finding and obstacle-avoidance-type tasks (Figure 1), and have not been concerned with character believability.

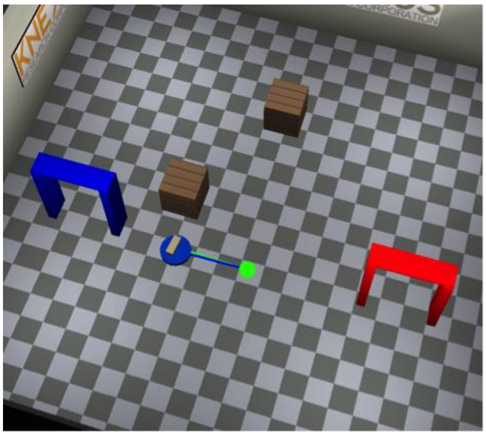

Figure 1. An eBotworks scene with an eBot performing obstacle avoidance.

In previous work [7], we designed scenarios showcasing emotion-influenced perception for possible future implementation in eBotworks. We then discussed how the implementation of these scenarios might be achieved with existing components of the framework.

We will first reiterate these scenarios before we explain how the newly-proposed mechanisms can be used to achieve them. The scenarios are based on the following assumptions: (1) the agent is a Rebel Agent [6] endowed with an autobiographical memory model in which memories are connected to emotions, (2) default perception is global-first, (3) agents have current "moods" (emotional states) which can be neutral, positive or negative, with the "neutral" mood being the default one, (4) moods can change as a result of perceiving scenes evoking autobiographical memories with emotional associations, (5) mood affects perception in the ways described in Section 2, (6) all scenarios take place on the same map, (7) 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, (8) 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.

- *Scenario 1*: 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.
- *Scenario 2*: On the way to its target location, the agent perceives a box. In the agent's autobiographical memory, the box has positive emotional associations. 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.
- *Scenario 3*: On the way to its target location, the agent perceives a box. In the agent's autobiographical memory, the box has negative emotional associations. 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".

4 Case-Based Reasoning for Location Ecphory

Ecphory is the remembrance, caused by a memory trigger, of a past event. In the case of location ecphory, this trigger is a location with which the memory is associated.

Gomes, Martinho, and Paiva [14] use map coordinates as location-ecphory triggers. While this is easier from a practicality 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 a memory cue is invalidated.

Retrieving stored memories is a natural match for the case-based reasoning model, which was inspired by the psychological mechanisms underlying memory storage and recollection. Furthermore, case-based reasoning literature contains ample coverage of similarity measures between complex case structures that are not trivially comparable, including graphs, plans, and case structures based on object orientation, which is precisely what we need for implementing our Rebel Agent prototype in eBotworks. By using case-based reasoning similarity measures, we intend to expand location ecphory beyond just map coordinates.

4.1 Case Structure and Similarity Measures

To achieve the emotional location-ecphory effect we are aiming for, each case should contain two essential pieces of information: (1) a past percept, and (2) an emotional reaction associated with that percept.

The ways in which we model these pieces of information can vary in complexity. The percept can be a complex scene or a very specific subscene, such as an individual object or something slightly more general such as a set of objects on a table. The emotional reaction can consist of a simple, basic emotion (e.g. "joy") or of a complex, layered conglomerate of emotions, each experienced at a different degree of intensity.

Due to the characteristics of our simulation platform, we are, for now, focusing on visual ecphory triggers, although triggers of a different nature (e.g. gustatory and olfactory) certainly function in the real world.

In choosing our case structure, we are influenced by the description that Navon [16] gives of 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. Global-first processing proceeds from global scenes, local-first processing from local ones. We do not, however, aim at matching any psychological model of perception differentiation perfectly through our case representation.

To approximate this hierarchical structure, we propose a model inspired by object-oriented ([3][2] - Section 4.4) and graph-based ([19][2] - Section 4.5) case structures.

A scene hierarchy is not equivalent to a class inheritance hierarchy, though there are clear similarities between the two. The reason is that in a class hierarchy, classes lower down in the hierarchy incorporate the attributes of classes higher up, whereas in the scene/subscene hierarchy, the inverse takes place: the root scene incorporates information from all lower nodes, because the complete scene is composed of all subscenes.

It is to be noted that the rather simple description above does not accurately capture human perception, in which a global scene is perceived as a general outline with vague details that become clear while travelling downwards in the hierarchy. Therefore, the details in the lower nodes are then incorporated (potentially completely) into the higher nodes. If perception proceeds in a global-first manner and is not prolonged, these lower levels may not be reached.

The similarity methods of Bergmann and Stahl [3] allow objects at different levels in the class hierarchy to be compared. This is especially useful, as we have no guarantees that two subscenes we are comparing are at similar hierarchical levels.

However, our situation is even more challenging: not only are the scenes that we are comparing different and at different hierarchical levels, but even their respective hierarchies can be different and correspond to varied scenes (unless the scenes that can be perceived are highly controlled and limited). Despite this challenge, we believe that the local and global similarity measures proposed by Bergmann and Stahl [3] can be adapted to be used for local and global perception, respectively. The perception setting of the agent at a given time (e.g. global after perceiving the box in Scenarios 1 and 2; local after perceiving the box in Scenario 3) will determine where in the hierarchy we look for the similarity.

For simplification, we can assume that the cases are collections of objects, and do not take into account the spatial positioning of the objects in a scene in relation to one another.

4.2 Populating the Case Base

In order to populate a case base consisting of "memories" of percepts and associated emotions, we must first provide a mechanism allowing agents' percepts to be associated with emotions.

Truly human-like agents would be able to generate emotions themselves. This would be partially based on (1) the personality with which the agent would have been endowed (which could dictate, for example, that the agent is not easily frightened), and (2) general rules about ways in which people tend to react to certain situations (e.g. a gruesome scene tends to cause shock). Thus, making agents able to generate emotions in response to percepts would require providing them with at least one of these two models.

We are interested in exploring a knowledge-light alternative to this challenge. This approach can leverage the chat interface of eBotworks (or alternative eBotworks mechanisms) and is based on the idea of having human users direct the agent on how to "feel" in certain situations. Thus, the agent acquires an "emotional baggage" derived from that human user's personality or a "role" that the human user chooses to play. Some bots, for instance, could be directed to be more "impressionable" than others.

Let us re-examine Scenario 3, where the agent perceives a box with negative emotional associations. With this approach, this association would not exist because the bot previously got hurt in the vicinity of the box, but rather because the bot was previously told that the box should make it "feel sad".

While we only propose this mechanism for the purpose of attaching specific emotions to scenes, it could later be applied more broadly within the context of motivation discrepancies and Rebel Agents. For instance, it could also be used to assign meaning to scenes, so that the agent can match scenes similar in meaning (e.g. "a quarrel") rather than just in their constitutive elements. With this ability, agents can then match emotion to meaning (e.g. witnessing a quarrel causes stress), rather than just to specific scenes and subscenes.

Currently, the chat interface of eBotworks is used to issue commands to agents in a simulated environment. For example, a user can enter "Go here" and click on a location on the current map; if the command is successful, the agent reacts by moving to the specified location.

To explain how this system could be used for our purposes, let us first assume that the bot is facing a scene containing a box. One option would be for the user to simply say one of several words corresponding to several emotions "understood" by the system, e.g. "sad". In this case, the agent would take a "snapshot" of the scene it is facing and store it together with the associated emotion, sadness.

However, memories of strong emotions can be associated with very specific subscenes, rather than to an entire complex scene (e.g. excitement associated with a logo on the envelope containing a college acceptance letter). Moreover, the subscene that attention ends up focusing on in such situations is not necessarily related to the emotion itself. Instead, it could contain items that just happen to be there when the emotionally charged event occurs (e.g., a cup that happens to be on a nearby table while a severe argument is taking place).

To handle this possibility, we can allow the user to specify an object in the scene to which to associate the emotion by clicking on the object first, then saying the word corresponding to the emotion. In Scenario 3, clicking on a box then saying "sad" can cause the agent to switch to a sad mood and experience local interference in perception. Another necessary addition to typical eBotworks usage will be to have the agent convey, through console messages, (and, later, possibly, through visual representations on the map) what objects it is currently focusing on and what moods it is experiencing. This will enhance believability by providing insight into the agent's motivations and into the emotional justification behind its actions.

5 Conclusions

We have discussed using the case-based model for the purpose of creating location-ecphory-based motivation-discrepancy mechanisms for Rebel Agents, addressing the challenge of retrieving emotionally-charged past percepts and comparing them to current ones.

Our two main contributions herein are:

(1) Exploring a case-based reasoning context for motivation-discrepancy-perception in eBotworks Rebel Agents.

(2) Proposing the use of chat-based user input for creating the agents' "emotional baggage", potentially sparking "rebellion".

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