Building Test Cases for Video Game-Focused Computational Models of Emotion

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Abstract. Believable Non-Player Characters (NPCs) are a crucial component of narrative-driven games. An important aspect of believable characters is their contextually-relevant reactions, which is often driven by emotion in humans. The plausibility of NPCs' "emotions" partly depends on their psychological validity. A Computational Model of Emotion (CME), grounded in emotion theories and/or models from psychology, is an attractive solution. Play-testing believability can be expensive. Theory-independent acceptance tests offer a cheaper pre-test of a CME's output against expected responses. We propose the *first* methodology for creating verifiable, replicable, and reusable test cases with known believable characters from professionally-created stories.

Keywords: Believable Agents · Emotion Generation · Test Cases

1 Introduction

Player engagement is a fundamental goal of video games and has a key role in player satisfaction—"the degree to which the player feels gratified with his or her experience while playing a video game" [28, pp. 1220]. Some video games engage players with narrative [28,30,42], which is often *character-driven*. One cannot imagine *Mass Effect 2* [2] without your crew mates, or *Portal* [38] without GLaDOS—the Non-Player Characters (NPCs) that fill important narrative roles [11,40]. Players have said that NPCs help them connect to a game world [7], and can get emotionally attached to them [3] such that their relationships with NPCs influence their interactions with the game. This kind of attachment can deeply engage players [15,43]. Some games, like *Final Fantasy XV*, encourage the attachment between player and NPC through their design [29]. This "character experience" depends on the NPC's *believability*, which helps players maintain the belief that the NPC has their own thoughts and personality.

Believable characters, central to literature and film, "...allows the audience to suspend their disbelief and...provides a convincing portrayal of the personality they expect or come to expect [from the character]" [23, pp. 1]. Believability for any character depends on the situational context and their personality [23,31]. What "believable" means also depends on the application domain—the expectations in entertainment differs from those in soft skills training [25]. In short: for an NPC to be believable, it must behave reasonably within the context of their world. Generally, NPCs are believable when they [23,39]:

– Appear to be self-motivated,
– Appear to be aware of what is happening around them, and
– React in ways appropriate for their surrounding context while adhering to their personality.

Emotion is a key element of believable character design [11,23,39]. They help convey a character's goals and desires (*self-motivated*) by showing their *awareness* of, *responsiveness* to, and care (*personality*-driven) for their surroundings [4,31]. Thus one way to improve an NPC's believability is for them to react emotionally to their surroundings [42]. We define *emotion* as a short-term affective state representing the coordinated physiological and behavioural response of the brain and body to events that an organism perceives as relevant [12,34]. Emotion is also characterized by its high intensity relative to other types of affect (e.g. personality, mood), its tendency to come and go quickly, its association with a specific trigger, and clear cognitive contents [4,16,32].

Believable NPCs depend, in part, on the *plausibility* of their behaviours [21], which are directly influenced by their *psychologically validity*—their grounding in knowledge of emotion [5], including "normal" and "abnormal" behaviours. A Computational Model of Emotion (CME) is one way to do so as its design relies on emotion theories [26], ensuring a foundation for psychologically validity.

Evaluating players' subjective judgment of believability [21,22] for NPC emotions requires at least one user study, which can be expensive to plan, execute, and analyze. Having some pre-tests to evaluate a CME on "obvious" scenarios with an expected emotional output is preferable. It is not enough to test a CME's implementation because that cannot determine if it *behaves* as expected (i.e. satisfies its external requirements). CMEs require acceptance tests derived from behaviour specified independently of specific theories, models, and/or CMEs. Once these tests pass, then it might be time to run user studies. However, there are no known design methods for creating CME test cases—possibly because the question is how "realistic" or "believable" its behaviours are [26].

A CME for creating believable NPC emotions aims to produce specific aspects of emotion without care for the specific structures, processes, and mechanisms behind them [26]. Similarly, acceptance test cases should focus on what makes emotion believable. Storytellers—such as novelists, playwrights, and actors—are an excellent source for such tests because they know how to express emotion in their characters [24,31]. Thus we want to build test cases from stories with characters where the following are known [35]:

1. A character's narrative design (goals, motivation, current state, etc.),
2. Aspects of the current world state relevant to that character, and
3. That character's emotional reaction to the world state.

The character's design and the current world state are inputs and the character's reaction is the expected output. This information must be reproducible and specific enough that it can be programmed. This build confidence that the test cases themselves are reasonable for CME validation.

Our contribution is to propose a first methodology for building acceptance test cases and to provide some carefully worked examples.

2 Test Case Input Types

Recalling that believable characters must appear to be self-motivated, aware of what is happening around them, and react appropriately in the context while adhering to their personality (Section 1), the "data" that contribute to a character's emotion state can be split into two groups:

1. Local data that changes between scenarios (i.e. aware of what is happening around them, react appropriately in the context), and
2. Global data that does not change or changes very slowly (i.e. self-motivated, adhering to their personality)

where the latter improves the coherence of the character's behaviours [25]. We similarly divide our test case inputs into "transient" (i.e. local) knowledge about *what* is happening to a character and "persistent" (i.e. global) knowledge *about* them.

2.1 "Transient" Knowledge

Emotion is a short-term state related to events (Section 1). To understand how a story event affects a character, we need to know how an event changes the story's "world state". As the "world" evolves independently, emotion evaluation happens concurrently with each event that is significant to one or more characters.

Audiences build conceptual models of a character's internal state from their visible *actions* [37]. Thus, we must carefully examine story events and their impact on the characters to collect the following in "transient" knowledge:

- The character's action(s) and dialogue,
- The character's physical state (e.g. injuries),
- If other characters and/or entities (e.g. the environment) are present/related to the character's action(s):
  - The character's relation to them,
  - Their action(s) and dialogue (actual or the character's assumption of them), and
  - Their physical state.

2.2 "Persistent" Knowledge

To understand what events a character deems *relevant*, they must possess some static—or very slowly changing—attributes, such as personality and goals. These help explain a character's motivation and their world perception, which are "persistent" knowledge because they are tied to the character rather than the "world".

A character's important actions are the ones that they deem *useful*. We interpret this as a character trying to obtain or preserve a *desirable* (to themselves) "world state". *How* a character performs those actions is also important because it illustrates how they perceive the world. From this, we can deduce the following in "persistent" knowledge about a character:

- Goal(s)/motivations, ranked by relative priority to the character,
- Personality traits, and
- Principles and preferences.

3 Building Test Cases from Stories

The "expected output" of an acceptance test case is a character's emotional reaction to a situation, phrased in terms of known behavioural and expressive characteristics of emotion kinds/categories or affective dimensions (we use "emotion kinds" going forward). The inputs—the factors causing the character's emotional reaction—are less clear. We must infer them from narrative elements. This inference step makes a methodology important for replicability due to the inherent subjectivity of character and story interpretation. Specifically, the methodology must guide the development of subjective interpretations from an objective investigation of a character, like a detective at a crime scene [19]. We propose a five-stage methodology to build acceptance test cases from stories:

1. Using the CME's target domain, identify a source medium (e.g. literature, film, theatre) to gather information from
2. Using the source medium and the CME's expected emotion kinds, build *profiles* for each emotion using knowledge of how storytellers encode them in their medium and, to build in some psychological validity, information from affective science
3. From a specific instance of the source medium, choose a character to analyze and identify data collection "trigger points" (e.g. changes in a character's emotion):
   (a) Using the "profiles", identify the emotion and record elements of the "profile" that apply to the character at that moment
   (b) Record elements of the scene that might have contributed to the emotion's elicitation (i.e. "transient" knowledge)
4. At the end of data collection, organize the information and infer "persistent" knowledge about the character, deducible from observations such as the character's tendencies to act (e.g. always greeting a certain entity when they appear) and patterns of elements across scenes (e.g. the character is only calm when they have a particular item)
5. Translate natural language descriptions into formal statements (e.g. "close to death" could become "$\texttt{health} \leq 5$ `units`"), recording how statements from the character analysis map to mathematical representations

This methodology relies on *character studies/analyses*, a literary analysis tool for examining a character's external aspects (e.g. physical description, relationships/social status, actions, dialogue) to deduce their internal ones (e.g. personality, motivations, emotions) [13]. This process provides a guide for identifying and systematically organizing salient aspects of a character to support deductions about them. Many aspects of literary works also apply to theatre. In the broadest sense, a character is an actor in a performance (medium) who delivers their lines (dialogue) following stage directions (storyteller-planned actions).

In the context of character analysis, "persistent" information is usually implicit and must be inferred from multiple sets of "transient" knowledge. Thus, character analysis is easier when the character appears frequently (i.e. main characters).

4 Example

We will build a test case for *Sadness* in the context of a CME for game development, which we will call EMgine ("Emotion Engine").

Choosing a Test Case Source Medium similar to video games helps reduce the time, effort, and potential mistakes associated with translating a storyteller's tales into test cases. Broadly, films are great because they too are an audiovisual medium. A character's emotional responses are most evident because there are more, clearer cues to signal it than words alone (e.g. body language, facial expressions, vocal tone). Animated films, in particular, are likely best for EMgine because they are grounded in, yet not limited by, reality: "In order to depart from reality, [animation] has to be based *on* reality." [41, pp. 34]. Animators often use live action film as inspiration and reference for their work [37]. Walt Disney famously brought performers and animals to the studio for his animators "...to try to capture a more realistic believable figure" [18]. When casting for live action references, care was taken to "...select an actor whose natural voice and mannerisms are caricatures of a normal person's." [37, pp. 550] likely because caricatures are the most unambiguous depictions of real behaviours [23]. Animators then "...accentuate and suppress aspects of the model's character to make it more vivid" [41, pp. 34] using their own knowledge and observations [17]. These caricatures include emotion, making it easier to identify what a character is experiencing and deduce the eliciting factors. Film scene reenactment has proven useful for evaluating the influence of CME parameters on viewer perceptions of animated agents [1], so it is a reasonable hypothesis that they would also be good resources for building test cases.

Literature and video games can also be used, but present some real difficulties. Literature has neither a native audio or visual component, leading to inconsistent readings due to personal interpretations. Audio and illustrated versions of these works are themselves interpretations of text-based descriptions, so they are indirect references to the author's intent. Video games are also not reliable as a source due to player agency. Since a player's role cannot be entirely scripted and their actions vary between sessions, their influence on the game state varies. This makes it more difficult to reproduce the scenario and, consequently, could make test case synthesis less reproducible.

Building Emotion Profiles involves describing the characteristics and observable signs of emotion that others can reference to recreate test cases. A core feature of the discrete (categorical) perspective on emotion is distinct emotion kinds distinguishable with sets of observable features [4,36]. Therefore, it is the primary resource for building EMgine's emotion profiles. Each profile describes (illustrated using EMgine's *Sadness* profile, see Annex A for complete version):

(a) The emotion's purpose, cognitive impact, and how it changes at different intensities (e.g. *Sadness* is defined by loss [8,33]. As the intensity increases, people tend to become less active, withdrawing into themselves and away from their surroundings.). This provides a reference for deducing “transient” and “persistent” knowledge about a character.

(b) Action tendencies, physiological changes, and verbal and nonverbal signals (e.g. The action tendencies in *Sadness* are passive: withdrawal by the individual while unintentionally signalling for help. Others can perceive this as inaction [20]. Although it is usually accompanied by strong non-verbal expression to signal for help—notably crying—there are few vocal, verbal, or nonverbal expressions [33]). Together with facial expressions, this serves as a guide for identifying what emotion a character is experiencing.

(c) Facial expressions associated with the emotion (e.g. The inner corners of the eyebrows are drawn together and upwards in *Sadness*, which can cause creases to appear between them and on the forehead [9,14]. In the lower face, the outer corners of the mouth are drawn down and become more exaggerated as the intensity of the emotion increases. Tension in the cheek muscles increases with the intensity of *Sadness*, causing them to rise.). Together with action tendencies, physiological changes, and verbal and nonverbal signals, facial expressions are a guide for identifying what emotion a character is experiencing. This is especially useful for identifying animated character emotions due to their caricaturisation.

(d) Examples (e.g. Elsa from Disney’s *Frozen* [6] experiences intense *Sadness*, i.e. *Grief*, when her sister becomes solid ice. Her *Grief* is shown via her facial expression, bodily collapse, hanging onto her sister’s body, loud sobbing, and vocal denial of the situation.), to demonstrate how different parts of the profile appear in the source medium.

Collecting Local “Transient” Knowledge about Elsa, extending the *Sadness* profile example, we see that she is primarily expressing *Sadness* with body language (Table 1). Anna’s physical state (frozen solid) is most likely the cause because *Sadness* is defined by loss, such as the death of loved ones. We also note that Elsa was already experiencing *Sadness* before this, reacting to news that Anna was dead because of Elsa’s powers (“Your sister is dead...because of you.”).

Inferring Global “Persistent” Knowledge about Elsa, we focus on her personality and goals. Elsa’s personality helps contextualize her responses to the world. All NPCs have at least one goal of some form [5] (e.g. “watch the race”, “generate income”), serving as a common nexus between the source medium and EMgine’s aim to create believable NPCs with emotion. Animated characters often have simple goals and personality [27]. Table 2 summarizes the relevant parts of Elsa’s personality. We examine one goal in detail: `Protecting Anna`.

Elsa does not want to harm anyone, especially those close to her (Distressed when she injures Anna as children; “No. Don’t touch me. I don’t want to hurt you.” to her parents during “Do You Want to Build a Snowman?”). She is particularly concerned with keeping Anna safe, evident by Elsa’s self-isolation after harming Anna with her powers when they were playing as children and after arriving at the North Mountain after the coronation party (in “Let it Go”). Elsa

Table 1. Example: Summary of "Transient" Knowledge About Elsa

In Scene An Act of Love	**Approx. Time** 1:26:24–1:27:08
Character Elsa	**Emotion** *Grief* (Intense *Sadness*)
	
Actions	Loud sobbing; Hanging her head; Hugging Anna's shoulders (not supporting herself with her legs/feet) and slowly releasing her hold (kneeling at the end); Powers are not active (initially stopped when Hans told her that she killed Anna, mirrors their parents' funeral during "Do You Want to Build a Snowman?"),
Dialogue	"Anna! Oh, Anna...no...no, please no." (pleading tone)
Physical State	Uninjured; Not in danger of injury
Character	Anna
Relation	Little Sister (Anna is 18 to Elsa's 21); Best Friend (from "Do You Want to Build a Snowman?", reunion at coronation party)
Actions	–
Dialogue	–
Physical State	Frozen solid ("dead")

Table 2. Example: Summary of "Persistent" Knowledge About Elsa's Personality

Elsa is a central character in Disney's 2013 film *Frozen* [6]. She presents herself as a calm, reserved, and regal person, but also demonstrates a kind and generous nature (e.g. allowing young Anna to wake her during the night to play, creating a skating rink for the people of Arendelle in the summer). However, the danger posed by her powers make her insecure, depressed, and anxious. Elsa was born with the power of ice and snow, which allows her to conjure, manipulate, and create sentient (e.g. Olaf, Marshmallow) and non-sentient (e.g. palace, skates) constructions from them. However Elsa's powers can cause harm if uncontrolled. Thus Elsa believes her powers make her monstrous. She wears gloves, believing that they help her control her powers ("Conceal it, don't feel it"), but falsified when she uses her powers to escape her jail cell by freezing manacles that completely cover her hands. Instead, Elsa manifests her powers unconsciously when she is severely distressed and/or frightened (e.g. after injuring Anna when they were children, at the overwhelming coronation party, discovering that Arendelle is frozen, escaping execution). In contrast, Elsa appears to have full control of her powers when not under stress (e.g. playing as children, "Let it Go", deicing Arendelle, making a skating rink in the castle courtyard).

also demonstrates her desire to protect Anna by refusing to bless her engagement to Hans ("You can't marry a man you just met [Anna]...You asked for my blessing, but my answer is no."); by forcing Anna to leave the ice palace without her after coming for her ("I'm just trying to protect you [Anna]."); and by asking Hans to take care of Anna after her execution ("...Just take care of my sister."). This differs from her desire to protect her kingdom (experiences fear when Anna tells her Arendelle is frozen and distress when she sees it from her prison cell) and herself (asking for Anna to be cared for after Elsa's execution). Elsa also has no qualms with using her powers for defence (fighting thugs in her ice palace).

Translating Character Analyses into Test Cases should be implementation-agnostic for reusability. We use "fuzzy" values like percentages, the set $\{\texttt{Low}, \texttt{Mid}, \texttt{High}\}$, and the constant `MIN` to avoid over-specification. This test case is small for illustrative purposes, but can be extended. We define the following types:

– World State View (WSV) $\mathbb{S}$, representing a *subset* of variables in the game "world" $\mathbb{W}$ (i.e. $\mathbb{S} \subseteq \mathbb{W}$) relevant to the character;
– World Event $\mathbb{S}_\Delta$, representing an *event* as a change to a *subset* of game "world" variables. The next WSV is given by applying the event to the current WSV (i.e. $\texttt{apply}() : \mathbb{S} \times \mathbb{S}_\Delta \to \mathbb{S}$);
– Goal $\mathbb{G}$, is a predicate on a WSV ($\texttt{goal} : \mathbb{S} \to \mathbb{B}$) that a character wants to satisfy, and its relative importance in $\{\texttt{Low}, \texttt{Mid}, \texttt{High}\}$; and
– Emotion Intensity $\mathbb{I}$, in $\{\texttt{Low}, \texttt{Mid}, \texttt{High}\}$.

Assuming that the characters have properties `Health` and `IsAlive`, we define Elsa's goal to `Protect Anna` as:

$$\texttt{ProtectAnna} : \mathbb{G} = \{\texttt{goal} = \{\texttt{Anna.Health} \geq 75\% \land \texttt{Anna.IsAlive}\},\\ \texttt{importance} = \texttt{High}\}$$

from our "persistent" character knowledge. We model $\texttt{Health} = 0$ as unconsciousness (a changeable state) and $\texttt{IsAlive} = \mathit{False}$ as a permanent death state, to reflect the ability to "revive" unconscious characters.

We use `Health` in `ProtectAnna` to reflect Elsa's fear of hurting others with her powers, which would be physical injuries. We chose the value 75% to reflect Anna's fearless and impulsive actions, which often leads to minor injuries like scrapes and bruises that Elsa would affectionately disapprove of. We mark goal importance as `High` because Elsa's responses in the story are strongest when Anna is involved.

From the "transient" knowledge about the scenario, we set Anna's health in the *current* world state $\texttt{S}_i : \mathbb{S}$ below Elsa's goal ($h \in (\texttt{MIN}\%, 25\%]$) and Elsa's current *Sadness* intensity as `Mid`, reflecting that unmet, transient goal component:

$$\texttt{S}_i : \mathbb{S} = \{\texttt{Anna.Health} = h, \texttt{Anna.IsAlive} = \mathit{True}\}; \qquad \texttt{Sadness}_i : \mathbb{I} = \texttt{Mid}$$

This WSV reflects Elsa's reaction to *hearing* that Anna is dead rather than *seeing* it, which she perceives as Anna being seriously injured rather than dead

($\texttt{MIN}\% < \texttt{Anna.Health} \leq 25\% \land \texttt{Anna.IsAlive}$). Elsa's *Sadness* is still elevated by the news because her goal, `ProtectAnna`, is currently unsatisfied.

The event of concern is Anna becoming solid ice, i.e. dying ("Anna, your life is in danger...to solid ice will you freeze, forever."):

$$\texttt{AnnaFreezes}_{\texttt{E}} : \mathbb{S}_{\Delta} = \{\texttt{Anna.IsAlive} = \textit{False}\}$$

which when applied to $\texttt{S}_i$ produces

$$\texttt{S}_{i+1} : \mathbb{S} = \{\texttt{Anna.Health} = h; \texttt{Anna.IsAlive} = \textit{False}\}.$$

Finally, we set the expected output as $\texttt{Sadness} : \mathbb{I} = \texttt{High}$ (completed test case in Table 3). If a CME's emotion intensity function does not accept $\texttt{Sadness}_i$ as an input, a function $\texttt{Combine}(i_1 : \mathbb{I}, i_2 : \mathbb{I})$ should produce the expected output.

Although both world states $\texttt{S}_i$ and $\texttt{S}_{i+1}$ fail to satisfy `ProtectAnna`, there is a subtle difference between them: `Anna.Health` is a changeable quantity while `Anna.IsAlive` is not. This reflects *world knowledge* and *self knowledge* (about one's one goals) that a CME needs to know, but that do not need to be embedded in test cases. Nevertheless, it is the reason for the intensity of Elsa's *Sadness* (see Table 4 for the test case resulting in $\texttt{S}_i$).

Table 3. Example: Test Case of Elsa's *Grief* When Anna Becomes Solid Ice

Setup	$\texttt{ProtectAnna} : \mathbb{G} = \{\texttt{goal} = \{\texttt{Anna.Health} \geq 75\% \land \texttt{Anna.IsAlive}\}, \texttt{importance} = \texttt{High}\}$, $\texttt{Sadness}_i : \mathbb{I} = \texttt{Mid}$, $\texttt{S}_i : \mathbb{S} = \{\texttt{Anna.Health} = h, \texttt{Anna.IsAlive} = \textit{True}\}$ where $h \in (\texttt{MIN}\%, 25\%]$
Input	$\texttt{AnnaFreezes}_{\texttt{E}} : \mathbb{S}_{\Delta} = \{\texttt{Anna.IsAlive} = \textit{False}\}$
Expected Output	$\texttt{Sadness}_{i+1} : \mathbb{I} = \texttt{High}$

Table 4. Example: Test Case of Elsa's *Sadness* When Told That Anna is Dead

Setup	$\texttt{ProtectAnna} : \mathbb{G} = \{\texttt{goal} = \{\texttt{Anna.Health} \geq 75\% \land \texttt{Anna.IsAlive}\}, \texttt{importance} = \texttt{High}\}$, $\texttt{Fear}_i : \mathbb{I} = \texttt{Mid}, \texttt{Sadness}_i : \mathbb{I} = \emptyset$, $\texttt{S}_i : \mathbb{S} = \{\texttt{Anna.Health} = h_0, \texttt{Anna.IsAlive} = \textit{True}\}$ where $h_0 \in [75\%, 100\%]$
Input	$\texttt{AnnaHurt}_{\texttt{E}} : \mathbb{S}_{\Delta} = \{\texttt{Anna.Health} = h_1\}$ where $h_1 \in (\texttt{MIN}\%, 25\%]$
Expected Output	$\texttt{Fear}_{i+1} : \mathbb{I} = \texttt{Low}, \texttt{Sadness}_{i+1} : \mathbb{I} = \texttt{Mid}$

5 Discussion & Conclusion

Our proposed methodology for building acceptance test cases will not work for all CMEs (e.g. CMEs for emotion research must use "real world" empirical data). However, entertainment-focused CMEs should be able to use the same test suite. Standard test suites would thus be a common good for CME development.

We believe that our CME-independent methodology helps improve the objectivity, verifiability, and—consequently—confidence in the soundness of the test cases. We do not know how many test cases are necessary for evaluating a CME like EMgine, but one designer has claimed to analyze 600 scenarios for a model with twenty-four emotions [10]—an average of 25 per emotion. We aim to make this endeavour feasible with our methodology, providing a common approach for building acceptance test cases that allows for parallel case creation and a common, objective, player independent foundation for evaluating the believability of NPC emotions.

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