Concept Summary for EMgine: A Computational Model of Emotion for Enhancing Non-Player Character Believability in Games

Geneva M. Smith

Version 1.0 (October 23, 2022)

Geneva M. Smith
Dept. of Computing and Software—McMaster University

Revision History

Date	Version	Notes
October 23, 2022	1.0	• Initial version

1 EMgine Concept Summary

EMgine is a Computational Model of Emotion (CME) for Non-Player Characters (NPCs) to enhance their believability, with the goal of improving long-term player engagement. EMgine is for *emotion generation*, accepting user-defined information from a game environment to determines what emotion and intensity a NPC is "experiencing". How the emotion is expressed and what other effects it could have on game entities is left for game designers/developers to decide.

You can find all Software Development Artifacts (SDAs) related to EMgine at:

https://github.com/GenevaS/EMgine

Design Goals EMgine aims to provide a feasible and easy-to-use method for game designers/developers to include emotion in their NPCs, which they perceive to be challenging with the current tools and restrictions (Broekens et al., 2016). EMgine should:

- Be modular and portable such that game designers/developers can use it in their regular development environment
- Be flexible to allow game designers/developers the freedom to choose when, where, and which of EMgine's components to use
- Not require knowledge of affective science, psychology, and/or emotion theories to use
- Be efficient with respect to computational resources
- Demonstrate that it positively impacts the player experience

Background: Computational Model of Emotion A *Computational Model of Emotion (CME)* is a software system that is influenced by emotion research, embodying at least one emotion theory as the basis for its stimuli evaluation, emotion elicitation, and emotional behaviour generation mechanisms (Osuna et al., 2020, p. 2, 14). This theoretical foundation helps define a CME's mechanisms, components, phases, and architecture which software engineering techniques and methods can implement (Osuna et al., 2021, p. 139).

There are two types of CME, differing in requirements and validation: *research-oriented* and *domain-specific* or *applied* (Hudlicka, 2019, p. 130–131; Osuna et al., 2020, p. 4–6). Research-oriented models emulate structures, processes, and mechanisms in order to understand their design and structure in biological agents. In software engineering terms, research-oriented systems are white-box models because they must have explainable behaviours and mechanisms that lead to affective phenomena. In contrast, domain-specific models aim to produce specific aspects of affective phenomena and need only mimic the processes that produce them. They are black-box models, where the transformation of inputs into affective phenomena is not important, as long as it has the desired effects. Generally, the degree of realism in the CME's mechanisms and behaviours is proportional to its design complexity (de Rosis et al., 2003, p. 83). This implies that domain-specific CMEs are unlikely to be exactly alike, even if they target the same domain. This also means that any emotion theory that satisfies the CME's needs is a viable choice.

An emotion generation engine that strives to create a more engaging player experience via believable NPCs is a *domain-specific* CME. This imposes fewer design constraints than a research-oriented system as it is not a strict model of affective phenomena (Sloman et al., 2005, p. 233).

Validation also differs from research-oriented systems, as it is defined by how well it engages a player rather than how closely it resembles true affective phenomena (Hudlicka, 2019, p. 131). This bodes well for converting informal emotion theories into the formal domain of software, which necessarily includes making assumptions and design decisions that existing research might not support (Marsella et al., 2010, p. 21, 23; Hudlicka, 2019, p. 130). A software engineering approach would systematically account for these factors, producing a well-designed CME.

Background: Player Engagement *Engagement* is a quality of the user experience describing a positive human-computer interaction (O'Brien and Toms, 2013, p. 1094). It is difficult to define, as people use it interchangeably with related concepts like flow and immersion (Brockmyer et al., 2009, p. 624; Turner, 2014, p. 33; Glas and Pelachaud, 2015, p. 944; Cairns, 2016, p. 81; Doherty and Doherty, 2019, p. 99:4). It can also have a subtly different meaning in a given context. This makes sense given that it overlaps with different elements of each concept, such as attention.

Engagement is a multidimensional concept encompassing cognitive, emotional, and behavioural influences measuring the user's temporal, cognitive, or emotional investment in the interaction (O'Brien and Toms, 2010, p. 62–63; O'Brien, 2016, p. 22). It is not an "all or nothing" quality, and can fluctuate over the course of the interaction (O'Brien, 2016, p. 19). Engagement is both a process and product of an interaction, existing both during and after human-computer interactions (O'Brien, 2016, p. 22). This dual nature of engagement results in a cyclical relationship—the process of engagement can lead to the product of engagement, which in turn influences the likelihood that the user will re-enter the process later (O'Brien and Toms, 2008, p. 945).

Engagement is difficult to measure due to its subjectivity and dual process-product nature, but it has common elements that makes it possible to compare experiences between users (Calvillo-Gámez et al., 2015, p. 41). These are broadly categorized as aesthetics, perceived usability, focused attention and reward.

Engagement with the game is a fundamental goal of games, having a key role in player satisfaction—"the degree to which the player feels gratified with his or her experience while playing a video game" (Phan et al., 2016, p. 1220). Players have a disposition towards being, and expect to be, engaged when they play (Cairns, 2016, p. 84). This could be because playing a game is a voluntary activity done for pleasure (Poels et al., 2007, p. 86–87; Yannakakis and Paiva, 2015, p. 459) in which they are an active participant (Mäyrä and Ermi, 2010, p. 94). Emotional engagement is one way to engage players, caused by the player's personal feelings aroused by an in-game event, character, asset attributes, or another player which causes them to want to continue playing (Schønau-Fog and Bjørner, 2012, p. 406–407).

Background: Believable Character A *believable character* "...allows the audience to suspend their disbelief and...provides a convincing portrayal of the personality they expect or come to expect [from the character]" (Loyall, 1997, p. 1). Believability is not limited to "smart" or "normal" characters because it depends on the situational context and the character's personality (Lisetti and Hudlicka, 2015; Loyall, 1997; Reilly, 1996). In short: an NPC must behave reasonably within the context of the game world. Generally, NPCs are believable when they (Lankoski and Björk, 2007; Loyall, 1997; Warpefelt et al., 2013):

- Appear to be self-motivated,
- Are aware of what is happening around them, and

- React in ways appropriate for their surrounding context while adhering to their personality.

Emotion, transient responses to changes in the environment (Lazarus, 1991), is one element of believable character design (de Melo and Gratch, 2015; Emmerich et al., 2018; Gard, 2000; Lankoski and Björk, 2007; Lisetti and Hudlicka, 2015; Loyall, 1997; Paiva et al., 2005; Warpefelt et al., 2013). It is an established aspect of believability in animation (Thomas and Johnston, 1995), and game designers have acknowledged its importance in NPC design (Hudlicka and Broekens, 2009; Yannakakis and Paiva, 2015).

Characters with emotion address the core features of believability because they convey a character's goals and desires (*self-motivated*) by showing their *awareness* of, *responsiveness* to, and care (*personality*-driven) for their surroundings (Bates, 1994; Broekens, 2021; Reilly, 1996). It follows that one way to improve an NPC's believability is to have them react emotionally to their surroundings (Togelius et al., 2013; Yannakakis and Paiva, 2015).

2 References

Joseph Bates. 1994. The Role of Emotion in Believable Agents. *Commun. ACM* 37, 7 (July 1994), 122–125. https://doi.org/10.1145/176789.176803

Jeanne H. Brockmyer, Christine M. Fox, Kathleen A. Curtiss, Evan McBroom, Kimberly M. Burkhart, and Jacquelyn N. Pidruzny. 2009. The Development of the Game Engagement Questionnaire: A Measure of Engagement in Video Game-Playing. *Journal of Experimental Social Psychology* 45, 4 (July 2009), 624–634. https://doi.org/10.1016/j.jesp.2009.02.016

Joost Broekens. 2021. Emotion. In *The Handbook on Socially Interactive Agents: 20 Years of Research on Embodied Conversational Agents, Intelligent Virtual Agents, and Social Robotics Volume 1: Methods, Behavior, Cognition*, Birgit Lugrin, Catherine Pelachaud, and David Traum (Eds.). ACM, New York, NY, USA, Chapter 10, 349–384. https://doi.org/10.1145/3477322.3477333

Joost Broekens, Eva Hudlicka, and Rafael Bidarra. 2016. Emotional Appraisal Engines for Games. In *Emotion in Games: Theory and Praxis*, Kostas Karpouzis and Georgios N. Yannakakis (Eds.). Socio-Affective Computing, Vol. 4. Springer International Publishing, Cham, Switzerland, Chapter 13, 215–232. https://doi.org/10.1007/978-3-319-41316-7_13

Paul Cairns. 2016. Engagement in Digital Games. In *Why Engagement Matters: Cross-Disciplinary Perspectives of User Engagement in Digital Media*, Heather O'Brien and Paul Cairns (Eds.). Springer International Publishing, Cham, Switzerland, 81–104. https://doi.org/10.1007/978-3-319-27446-1_4

Eduardo H. Calvillo-Gámez, Paul Cairns, and Anna L. Cox. 2015. Assessing the Core Elements of the Gaming Experience. In *Game User Experience Evaluation*, Regina Bernhaupt (Ed.). Springer International Publishing, Cham, Switzerland, 37–62. https://doi.org/10.1007/978-3-319-15985-0_3

Celso M. de Melo and Jonathan Gratch. 2015. Beyond Believability: Quantifying the Differences Between Real and Virtual Humans. In *Intelligent Virtual Agents (Lecture Notes in Computer Science, Vol. 9238)*, Willem-Paul Brinkman, Joost Broekens, and Dirk Heylen (Eds.). Springer International Publishing, Cham, Switzerland, 109–118. https://doi.org/10.1007/978-3-319-21996-7_11

Fiorella de Rosis, Catherine Pelachaud, Isabella Poggi, Valeria Carofiglio, and Bernadina De Carolis. 2003. From Greta's Mind to Her Face: Modelling the Dynamics of Affective States in a Conversational Embodied Agent. *International Journal of Human-Computer Studies* 59, 1–2 (July 2003), 81–118. https://doi.org/10.1016/S1071-5819(03)00020-X

Kevin Doherty and Gavin Doherty. 2019. Engagement in HCI: Conception, Theory and Measurement. *Comput. Surveys* 51, 5, Article 99 (Sept. 2019), 39 pages. https://doi.org/10.1145/3234149

Katharina Emmerich, Patrizia Ring, and Maic Masuch. 2018. I'm Glad You Are on My Side: How to Design Compelling Game Companions. In *Proceedings of the 2018 Annual Symposium on Computer-Human Interaction in Play (CHI PLAY'18)*. October 28–31, 2018, Melbourne, Australia. ACM, New York, NY, USA, 141–152. https://doi.org/10.1145/3242671.3242709

Toby Gard. 2000. Building Character. Gamasutra. Retrieved January 4, 2022 from https://ininet.org/download/gama-network-presents-building-character-by-toby-gard.doc

Nadine Glas and Catherine Pelachaud. 2015. Definitions of Engagement in Human-Agent Interaction. In *2015 International Conference on Affective Computing and Intelligent Interaction (ACII 2015)*. September 21–24, 2015, Xi'an, China. IEEE, New York, NY, USA, 944–949. https://doi.org/10.1109/ACII.2015.7344688

Eva Hudlicka. 2019. Modeling Cognition-Emotion Interactions in Symbolic Agent Architectures: Examples of Research and Applied Models. In *Cognitive Architectures*, Maria Isabel Aldinhas Ferreira, João Silva Sequeira, and Rodrigo Ventura (Eds.). Intelligent Systems, Control, and Automation: Science and Engineering, Vol. 94. Springer International Publishing, Cham, Switzerland, 129–143. https://doi.org/10.1007/978-3-319-97550-4_9

Eva Hudlicka and Joost Broekens. 2009. Foundations for Modelling Emotions in Game Characters: Modelling Emotion Effects on Cognition. In *Proceedings of the 3rd International Conference on Affective Computing and Intelligent Interaction and Workshops (ACII 2009, Vol. 1)*. September 10–12, 2009, Amsterdam, The Netherlands. IEEE Computer Society, Los Alamitos, CA, USA, 1–6.

Petri Lankoski and Staffan Björk. 2007. Gameplay Design Patterns for Believable Non-Player Characters. In *Proceedings of the 2007 DiGRA International Conference: Situated Play (DiGRA'07, Vol. 4)*. September 24–28, 2013, Tokyo, Japan. DiGRA, http://www.digra.org/, 416–423. http://www.digra.org/digital-library/publications/gameplay-design-patterns-for-believable-non-player-characters/

Richard S. Lazarus. 1991. *Emotion and Adaptation*. Oxford University Press, New York, NY, USA. ISBN 0-19-506994-3.

Christine Lisetti and Eva Hudlicka. 2015. Why and How to Build Emotion-Based Agent Architectures. In *The Oxford Handbook of Affective Computing*, Rafael Calvo, Sidney D'Mello, Jonathan Gratch, and Arvid Kappas (Eds.). Oxford University Press, New York, NY, USA, Chapter 8, 94–109. ISBN 978-0-1999-4223-7.

Aaron B. Loyall. 1997. *Believable Agents: Building Interactive Personalities*. Ph. D. Dissertation. Department of Computer Science, Carnegie Mellon University, Pittsburgh, PA, USA. Advisor(s) Joseph Bates. https://www.cs.cmu.edu/afs/cs/project/oz/web/papers.html

Stacy C. Marsella, Johnathan Gratch, and Paolo Petta. 2010. Computational Models of Emotion. In *A Blueprint for Affective Computing: A Sourcebook and Manual*, Klaus R. Scherer, Tanja Bänziger, and Etienne B. Roesch (Eds.). Oxford University Press, New York, NY, USA, Chapter 1.2, 21–41. ISBN 978-0-1995-6670-9.

Frans Mäyrä and Laura Ermi. 2010. Fundamental Components of the Gameplay Experience. In *DIGAREC Keynote—Lectures 2009/10*, Stephan Günzel, Michael Liebe, and Dieter Mersch (Eds.). Potsdam University Press, Potsdam, Germany, 88–115. ISBN 978-3-8695-6115-8.

Heather O'Brien. 2016. Theoretical Perspectives on User Engagement. In *Why Engagement Matters: Cross-Disciplinary Perspectives of User Engagement in Digital Media*, Heather O'Brien and Paul Cairns (Eds.). Springer International Publishing, Cham, Switzerland, 1–26. https://doi.org/10.1007/978-3-319-27446-1_1

Heather L. O'Brien and Elaine G. Toms. 2008. What is User Engagement? A Conceptual Framework for Defining User Engagement with Technology. *Journal of the American Society for Information Science and Technology* 59, 6 (April 2008), 938–955. https://doi.org/10.1002/asi.20801

Heather L. O'Brien and Elaine G. Toms. 2010. The Development and Evaluation of a Survey to Measure User Engagement. *Journal of the American Society for Information Science and Technology* 61, 1 (Jan. 2010), 50–69. https://doi.org/10.1002/asi.21229

Heather L. O'Brien and Elaine G. Toms. 2013. Examining the Generalizability of the User Engagement Scale (UES) in Exploratory Search. *Information Processing & Management* 49, 5 (Sept. 2013), 1092–1107. https://doi.org/10.1016/j.ipm.2012.08.005

Enrique Osuna, Luis-Felipe Rodríguez, and J. Octavio Gutierrez-Garcia. 2021. Toward Integrating Cognitive Components with Computational Models of Emotion Using Software Design Patterns. *Cognitive Systems Research* 65 (Jan. 2021), 138–150. https://doi.org/10.1016/j.cogsys.2020.10.004

Enrique Osuna, Luis-Felipe Rodríguez, J. Octavio Gutierrez-Garcia, and Luis A. Castro. 2020. Development of Computational Models of Emotions: A Software Engineering Perspective. *Cognitive Systems Research* 60 (May 2020), 1–19. https://doi.org/10.1016/j.cogsys.2019.11.001

Ana Paiva, João Dias, Daniel Sobral, Ruth Aylett, Sarah Woods, Lynne Hall, and Carsten Zoll. 2005. Learning by Feeling: Evoking Empathy with Synthetic Characters. *Applied Artificial Intelligence* 19, 3–4 (March 2005), 235–266. https://doi.org/10.1080/08839510590910165

Mikki H. Phan, Joseph R. Keebler, and Barbara S. Chaparro. 2016. The Development and Validation of the Game User Experience Satisfaction Scale (GUESS). *Human Factors: The Journal of the Human Factors and Ergonomics Society* 58, 8 (Dec. 2016), 1217–1247. https://doi.org/10.1177/0018720816669646

Karolien Poels, Yvonne de Kort, and Wijnand Ijsselsteijn. 2007. "It is always a lot of fun!" Exploring Dimensions of Digital Game Experience Using Focus Group Methodology. In *Proceedings of the 2007 Conference on Future Play (Future Play'07)*. November 14–17, 2007, Toronto, ON, Canada. ACM, New York, NY, USA, 83–89. https://doi.org/10.1145/1328202.1328218

W. Scott Neal Reilly. 1996. *Believable Social and Emotional Agents*. Ph. D. Dissertation. Department of Computer Science, Carnegie Mellon University, Pittsburgh, PA, USA. Advisor(s) Joseph Bates and Jaime Carbonell. https://www.cs.cmu.edu/afs/cs/project/oz/web/papers.html

Henrik Schønau-Fog and Thomas Bjørner. 2012. "Sure, I Would Like to Continue": A Method for Mapping the Experience of Engagement in Video Games. *Bulletin of Science, Technology & Society* 32, 5 (Oct. 2012), 405–412. https://doi.org/10.1177/0270467612469068

Aaron Sloman, Ron Chrisley, and Matthias Scheutz. 2005. The Architectural Basis of Affective States and Processes. In *Who Needs Emotions? The Brain Meets the Robot*, Jean-Marc Fellous and Michael A. Arbib (Eds.). Oxford University Press, New York, NY, USA, Chapter 8, 203–244. ISBN 978-0-19-516619-4.

Frank Thomas and Ollie Johnston. 1995. *The Illusion of Life: Disney Animation*. Disney Editions, New York, NY, USA. ISBN 978-0-7868-6202-3.

Julian Togelius, Georgios N. Yannakakis, Sergey Karakovskiy, and Noor Shaker. 2013. Assessing Believability. In *Believable Bots: Can Computers Play Like People?*, Philip Hingston (Ed.). Springer Berlin Heidelberg, Berlin, Heidelberg, Germany, 215–230.

Phil Turner. 2014. The Figure and Ground of Engagement. *AI & Society* 29, 1 (Feb. 2014), 33–43. https://doi.org/10.1007/s00146-012-0439-6

Henrik Warpefelt, Magnus Johansson, and Harko Verhagen. 2013. Analyzing the Believability of Game Character Behavior using the Game Agent Matrix. In *Proceedings of the 6th Digital Games Research Association Conference: DeFragging Game Studies (DiGRA'13, Vol. 7)*. August 26–29, 2013, Atlanta, GA, USA. DiGRA, http://www.digra.org/, Article 70, 11 pages. http://www.digra.org/digital-library/publications/analyzing-the-believability-of-game-character-behavior-using-the-game-agent-matrix/

Georgios N. Yannakakis and Ana Paiva. 2015. Emotion in Games. In *The Oxford Handbook of Affective Computing*, Rafael Calvo, Sidney D'Mello, Johnathan Gratch, and Arvid Kappas (Eds.). Oxford University Press, New York, NY, USA, Chapter 34, 459–471. ISBN 978-0-1999-4223-7.