Computational Affective Science

Joost Broekens
Joost.broekens@gmail.com
Man-Machine Interaction, TU Delft, The Netherlands

In the target article, Hudlicka points out very clearly that there are several key challenges in affective computing in general and computational modeling of emotion in particular. The lack of guidelines and the sharing of best-practices as well as failures are some of those challenges. These challenges are very relevant when one is interested in the development of computational models of emotion that are focused on being applied in particular domain, for example games, virtual avatars or social robots [1]. As Hudlicka shows, choices and assumptions have to be made when developing a computational model based on, e.g., an appraisal theory. More often than not, these choices and assumptions are left unaddressed in the final publications, and rarely are the object of experimental investigation, while it is precisely these choices that make the computational model run in the first place (e.g., some representation of a goal is needed, but how is a goal represented in the agent?). Hudlicka provides an impressive overview of the different choices one has to make and the different options one has when computationally modeling emotion. It is therefore interesting to note that for many of these options it is unclear, not due to Hudlicka's overview but due to the lack of experimental data, why one should pick one or the other if one is interested in grounding the option in emotion psychology. For example, how and when to integrate (mix) emotions is a thorny issue that is far from solved. If one implements the OCC model [2] it is not clear how to mix emotions into the emotional state [3], and it is also not clear how the "appraisal tree" should be traversed computationally. A very simply choice between breadth and depth first already changes the order of affective attributions that arise given the appraisal of a specific situation. Also, the way the agent deals with how a belief is represented as well as how events are processed (in parallel, serial, prioritized, etc.) will influence the order of appraisal. So, it is without doubt that Hudlicka touches upon a major challenge in the computational modeling of emotion when she states that guidelines regarding how to model a particular affective phenomenon of interest are needed.

While addressing this challenge, Hudlicka presents a large collection of guidelines and choice options that can serve as a starter of a discussion about how to structure the process of developing a computational model of emotion. What could in my view be added are guidelines for the development of computational models aimed at the theoretical investigation of emotion, a research field I would like to call *computational affective science*. I would argue that for this field a slightly different approach is needed. In this reply I focus on this topic.

Apart from organizational issues, such as having interdisciplinary research teams, having joint publication outlets (e.g. books[1] and special issues[2]), and workshops[3], several guidelines that relate to research methodologies are of importance.

First, the *topic of investigation has to be meaningful to emotion psychologists*. This would include topics related to emotion processing in humans (e.g., the influence of arousal on attention, a detailed process of fear appraisal, the structure of the experience of emotion [1]), but exclude topics related to simulation specifics irrelevant to or too generic for emotion processing (e.g., the system is build in Java, the emotion architecture has a black box called "emotion" that influences another black box called "cognition"). This means that a clear hypothesis is needed about what the computational model is supposed to investigate. This hypothesis must be driven by psychology, and hence must be embedded within the psychological literature. Further, the model must be simple and tractable, at least those elements relevant for the emotional phenomenon under study. For example, if one is interested in approach and avoidance behavior, a simple but tractable model might suffice [4]. If one is interested in the relation between emotion and action selection, a simple conceptualization of positive and negative affect that relates to the selectiveness of action selection can be used [5, 6]. If one is interested in what an emotion *is* for an artificial agent, one might have to go back to the essentials of the relation between emotion, behavior and information processing [7].

Second, *focus on the minimal set of computational mechanisms needed*. As each choice in a model that is not related to the main hypothesis needs to be argued for, the best choice is to not have to make one. For example, if you are interested in the emergent nature of behavior emotion and cognition or the specific relations that might exist between decision making and affect, then build upon an existing cognitive architecture to avoid unnecessary assumptions [6, 8, 9]. Each assumption introduces the need to model that assumption and as mentioned earlier, the devil is in the computational details: what *is* a belief in my framework, what *is* a desire, what *is* time, how do I traverse an appraisal tree, how heavily should different appraisal components be activated? Most of these questions are mentioned by Hudlicka, but some of these need not be answered by you.

Third, *pay attention to the detail of your model's behavior and do not discard weird behavior as a bug*. If your model is simple and tractable and you find unexpected behavior, it is possible to find out if this was glitch in your understanding or model or in the theory used to build your model [10]. If it is something genuinely unexpected, then it pays off to investigate it, as it might be something new you have discovered. For example, when paying attention to the details of appraisals over time, one can find new patterns in how appraisal could work in the first place [11]. When formalizing appraisal, one might find new relations between the underlying system of beliefs and goals and the emerging emotions that would have to follow from the appraisal theory you formalized [12].

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[1] A Blueprint for Affective Computing, Oxford University Press, 2010
[2] Cognitive Systems Research Volume 1, Issue 1, 2009
[3] http://www.sem2011.org, Aug, 2011

Forth, *relate back your findings to experimental findings from psychology.* If you find something of interest, or something unexpected, it is worthwhile investigating if emotion psychologists already found similar behavior in experiments with humans. Referring to findings from psychology further grounds your own model, and facilitates emotion psychologists to find your study.

In this short commentary, I hope to have shown that for the development of computational models of emotion aimed at understanding emotion from a psychological perspective, additional guidelines are needed. I do not claim the presented set of guidelines is anywhere near complete, but I do feel that these guidelines should be taken into account and I hope to have added some fuel to the search for grounding models of emotion.

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