From Complete Coverage to Unified Emotion Representation

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1 Introduction

Representing emotions in agents is important for designing agents that behave like humans or are intended to interact with humans. Considering the critical role of the web, Emotion Markup Language [1] provides a significant endeavor to seek for a standard for representing emotions, and to strike a balance between practical applicability and scientific well-foundedness. However, this work is still very challenging.

First of all, there is no standard definition for emotions. Kleinginna [2] mentions that there are as many as 92 different definitions in the literature. For example, emotions are described as conscious states [3], cognitive processes [4], psychosocially constructed, dramatized feeling [5], or mental states that arise spontaneously, rather than through conscious effort. Some other descriptions involves adaptive dispositions, or evaluative judgments, or even social facts or dynamical processes [6]. Regarding the representation method of emotions, there are many possibilities as well. For example, we can consider first-order logic, multidimensional logic [7], some numerical measurement method as PAD (Pleasure - Arousal - Dominance) emotion scales [8], or something else.

Second, the emotion theory is not complete. As in [9], Ekman reveals the central issues in emotion research and theory in the words of many of the leading scientists working in the field. Davidson [10] gives a comprehensive road-map to the burgeoning area of affective sciences, and brings together the various strands of inquiry and the latest research in the scientific study of the relationship between the mechanisms of the brain and the psychology of mind. Other than the area of AI (Artificial Intelligence), emotions are also the focus of vigorous interest in philosophy, as well as in other branches of cognitive science [6].

The mentioned above issue shows the difficulty to seek for a standard emotion representation method and emotional mechanism. However, it also shows the needs of research in this area. For a standard emotion representation, we expect it has sufficient expressive power to cover most of the available emotions upon general cases, and at the same time, we expect it is simple and easy enough to use. On the other hand, if several major emotion representation methods are adopted, we hope they are compatible with each other. For example, through automatic recognition of emotions from some sensors, we may get some emotions

and represent it with human language such as happy, sad, etc. For another system, we are using PAD emotion scale to generate the response of the computer system. In this case, we then hope the emotions in vocabulary is compatible with the PAD emotion scale.

Thus, this paper will focus on: (1) How to obtain a vocabulary set to have a complete coverage of most emotions based on common sense; (2) How to balance the completeness of vocabulary coverage with the simplicity in using, and (3) The problem of compatibility among different representations. The provided opinions and proposed approaches are described as in the following sections, these may help to bring broader discussion in this area.

2 Lexicon-based Complete Coverage of Emotions

Regarding a complete coverage of emotions in vocabulary, an exhausted search upon human natural language can be considered. Other than that, there are several resources can be used.

The first one is Ballmer and Brennenstuhl's work [11]. This work proposes a classification upon an almost complete domain with about 4800 speech acts, and the authors claim they provide a "theoretically justified" classification "based explicitly and systematically on linguistic data." In this work, a category named "Emotion Model" is addressed, and there are 155 emotion speech acts listed. The concept of speech acts is originally developed by Austin [12]. He points out that human natural language can be viewed as *actions* and people can perform things by saying. The current ACLs (Agent Communicative Language), such as KQML (Knowledge Query and Manipulation Language) [13] and FIPA (Foundation for Intelligent Physical Agents) ACL [14], derive their language primitives from the linguistic theory of speech acts.

We believe these 155 emotion speech acts categorized through lexicon analysis could be good candidates for a better coverage of emotions. The only issue is that the classification for English is obtained by translating the verbs of a German classification, the names of the categories are not systematically chosen, and there is no formal semantic representation for the categories. However, most of these problems can be fixed by rebuilding the categories. Thus, we can endeavor herein to derive a reasonable set of categories from their theory, and to give a formal semantics using more typical English names, as [15].

Another resource we can use is some online tool like WordNet [16]. WordNet is a semantic lexicon for the English language. It groups English words into sets of synonyms called synsets, provides short, general definitions, and records the various semantic relations between these synonym sets. It has been used in automatic text analysis and artificial intelligence applications. Here we can use semantics of the words from WordNet to find a vocabulary set with better coverage of emotions.

3 Balancing Completeness with Simplicity

Based on lexicon analysis, we can obtain a vocabulary set with a complete coverage of regular emotions in human natural language. However this set could be too big for data processing. Thus some abstract level to express emotions should be considered.

If we adopt Ballmer and Brennenstuhl's clasification [11], as the categories reflect an ontological and a conceptual structuring of linguistic behavior, we can use the categories as an abstract level of representation. For example, the *Emotion Model* is the most speaker-oriented and focuses on representing kinds of emotional states of a human or agent, and [15] generates a set of foundational meaning units from the 155 emotion speech acts, as in the following Table 1. It gives the foundational meaning units of emotions that combine the idea from [17, 9], and the emotions are organized with consideration of positive, neutral, and negative values.

Table 1. Foundational Meaning Units of Emotional Speech Acts

+	0	-
happy	N/A	sad
love	N/A	hate
excited	nervous	angry
desire	hesitate	fear
N/A	shocked	N/A

In Table 1, each row represents a kind of meaning unit. In the first row, *sad* has the opposite meaning of *happy*. *Hate* has the opposite meaning of *love* in the second row. *Excited* represents a positive attitude to something with strong feeling, *nervous* represents a strong uncertain feeling about something, and *angry* represents a strong negative feeling about something. In the fourth row, *desire* shows a feeling to get something, *hesitate* shows no intentions or some uncertainty, and *fear* shows a feeling to avoid something. In the last row, *shocked* shows a neutral feeling about surprise.

To balance the completeness with Simplicity, user can choose different abstract level for data processing: the highest abstract level may include only the positive, neutral and negative emotions; the middle level can be any emotions in the Table 1; and the most detailed level can be any emotions from the original 155 emotions.

4 Compatibility among Different Representations

Different users may adopt different emotion representation methods, such as the set with 155 emotions from Ballmer and Brennenstuhl's clasification [11], or 22

descriptive emotions from OCC model [18], or three dimension PAD emotions [8]. A standard Emotion Markup Language is expected to have the power to represent all these different emotions. Meanwhile we also expect that all these different representations are compatible.

Thus it is desirable to find out kind of relationship between the different representations, and build a mapping between these different representations. This mapping should: (1) be consistent with the common sense, and (2) be consistent with the specific situations in the individual emotion model. Thus, a unified emotion representation can be achieved.

For example, if one user generates some emotions originally from an OCC based emotion model, such emotions are represented in the Emotion Markup Language. Another user gets these data and he / she wants to process the data with a PAD based emotion model, thus the corresponding PAD emotion representation will be needed. As a standard Emotion Markup Language, such compatibility function will be greatly useful. Thus the user who needs the PAD emotions can get the compatible copy of the OCC emotions with PAD representation. An endeavor to map OCC emotions to PAD emotions is described in [19], and we still need to figure out how to generate the specific PAD values on this case.

5 Conclusion

Above all, to develop a standard Emotion Markup Language is not easy, and to achieve a complete coverage of the emotions and unified emotion representation to facilitate the usage, the following features will be desirable:

Complete coverage: A complete emotion set based on lexicon analysis will be desirable to provide a sufficient expressive power. And two resources are suggested and described in Section 2.

Balanced completeness with simplicity: A complete emotion set could have sufficient expressive power, however it might be too big and complex for data processing. Thus, different abstract level of emotion vocabulary set is suggested, as described in Section 3.

Compatibility among different representations: To achieve a unified emotion representation to facilitate the usage, a standard Emotion Markup Language should be able to support different emotional representations and provide the compatibility among these representations. The details is described in Section 4.

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