Embedding of the Personalized Sentiment Engine *PERSEUS* in an Artificial Companion

Position Paper

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***Abstract*—The term Artificial Companion has originally been introduced by Y. Wilks [1] as "...an intelligent and helpful cognitive agent, which appears to know its owner and their habits, chats to them and diverts them, assists them with simple tasks...". To serve the users' interests by considering a personal knowledge is, furthermore, demanded. The following position paper takes this request as motivation for the embedding of the *PERSEUS*[1] system, which is a personalized sentiment framework based on a Deep Learning approach. We discuss how such an embedding with a group of users should be realized and why the utilization of *PERSEUS* is beneficial.**

I. Introduction

Over the last decade, the field of sentiment analysis has attracted a lot of attention in natural language processing and beyond. It has offered models with a number of alternatives [2]. However, a direct implementation of such models can be sometimes unwise, with a lack of reliability. The reason is that most of the existing research work focuses on semantic relations in text while other information – that may be influential to the understanding of the text – is less concerned. Examples are, particularly, the diversity of people regarding their habits, preferences, and opinions.

In this regard, *PERSEUS* is designed as personalization framework for the categorization of sentiment. It has been built to include such a diversity as a reflection of individuality. So far, we have realized three traits: First, people make different lexical choices in expressing their sentiments; Second, an individual's opinion towards a topic remains consistent within a period of time, and opinions on related topics are potentially dependent; Third, an individual's opinion can be related to the public opinion. To leverage all these traits, *PERSEUS* as in Figure 1, centers in a utilization of a recurrent neural network with long short-term memory [3] for its ability of preserving useful information over time and automatic feature learning.

Implementations on Twitter text have shown effectiveness of the framework for an enhanced, user-oriented understanding of the text. In this position paper, we argue that *PERSEUS* can be used as embedding in companion systems to improve intelligence in communication. The main concept of this embedding is to offer a shift in sentiment modelling that is tailored by the person a companion encounters with.

[1]PERSEUS is an ongoing research that currently at the first stage. For more information concerning PERSEUS, please contact the authors.

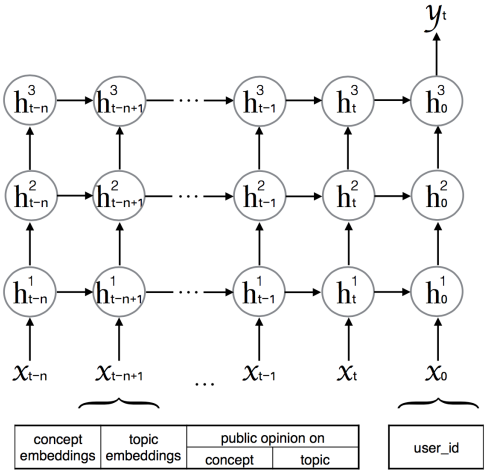

Fig. 1. Personalized recurrent neural network with two types of neurones at the input layer: the user index (x_0) and the concatenated components for representing a tweet of the user at a specific time point (x_{t*}).

II. Embedding into a companion

Companion technology, as a field of cross-disciplinary research, has played different roles in respect of the areas of application [4]. For a diverse number of applications such as social robots [5] and elderly companions [6], the detection of emotions and emotional states is a primary task for an interactive communication. Emotions, or sentiments to be more general, can be analyzed based on different resources, in which text or speech is one of the most direct signals that can be easily captured. Although it is easy to adapt an existing sentiment model to a companion system, it is much more desired to modify the model to acquire a higher level of user understanding. The literal sense of the name 'companion system' implies that such an agent should be able to provide companionship for a user or a group of users, therefore the underlined system has to offer an individualized analysis.

The individuality is mainly operated by evoking stored memory, and is essential to support a long-term relationship [7][8]. A single personalized model is sufficient when the companion is designed to serve one user, while multiple models are desired when serving a group of users. In the latter case, an extended storage is required and is featured with an indirect comparison between users. As a better alternative, a *PERSEUS* module can be used upon a traditional model of sentiment analysis for multi-user scenario without creating multiple models. The module is designed to extract useful information for each user, compare shared preferences between users, and find relations between topics or events with the goal of improving understanding, especially when lacking context.

A. Structure of PERSEUS

Neural networks require adequate data for training. For a personalized network, the lack of user-specified data is the major problem that makes the idea of building a model for each user infeasible. To solve the data quality issues like sparsity, *PERSEUS* has taken inspiration from Johnson et al. [9] and has added an additional token – the user_id in Figure 1 – to the input sequence indicating the identity of the user. By doing so, the network automatically memorizes valuable information for each user, and the information from different users are compared at the same time. Besides, an input sequence also contains a number of nodes indicating the current text x_t and the historical text x_{t-*} of the same user, and the nodes are ordered by the creation time of the text. Text at a specific time point is represented by embeddings of the text and the associated topic, together with the public opinions on the text and the topic. The network takes the input sequence, and updates the memory cells through a training process according to a preset of labelling y_t for the current sentiment state.

B. Multi-user scenario

There exists situations where an agent is applied to serve more than one user, for example a robot that receives requests from a group of users or an introductory companion that engages itself in a business fair. These situations reveal some desired features of a companion. First, a companion must differentiate between different users; Second, the companion should be able to get access to the information associated with each user, and guess a user's attitude towards a potential topic; Third, the companion should be able to compare between users; Last, the companion should analyze the users' preferences on use of words in expressing their sentiment besides extracting users' interests and opinions.

For each encounter between a companion and a user, the information required by the companion includes the user's identity, the text or speech uttered by the user, and the time flag of this encounter. Such information together with the extracted topic from the utterance and public opinions learnt from the past form an exact match of an input sequence of *PERSEUS*. The differentiation between users can be accomplished by external sensors and represented by the user identifier; *PERSEUS* is able to predict a user's sentiment on a topic if a related topic has been discussed between the companion and the user in the past – the relation between topics is found by comparing their embeddings, and a reference of opinion or emotion to a related topic is evoked from the memory; The comparison between users is enabled using the user identifier. Furthermore, the preferences on lexical choices can be fulfilled as well by including text embeddings in the input nodes.

C. Challenges

Although the embedding of *PERSEUS* seems straightforward, there remains some challenges. At each encounter, the information in memory cells relating the topic of the current utterance and the associated user is activated, and unrelated information is automatically forgotten. The memory can be traced back to the first encounter which is unnecessary in certain situations. For the scenario that an excessive number of users are engaging with the companion, it may cause a significant outburst in storage space and an increased computational complexity. For such an application, an additional forgetting mechanism should be purposed. Moreover, the companion is favored with the ability of constantly learning alongside the user(s), thus a transfer learning which updates the *PERSEUS* module after each encounter should be performed. However, the labelling mechanism must be defined for the training process. A solution is to apply a semi-supervised learning that an encounter is trained with label when there is a clear feedback from the user. Alternatively, a third party can be involved in labelling as an external observer. Another issue is to make the knowledge of the companion always up to date. For that, we can either update the embedded knowledge base manually or connect the companion with social platforms so that an automatic update is possible. An external resource of knowledge for a companion to understand new topics and to track public opinions is necessary to avoid biased understanding from the users.

III. Conclusion and Future Work

This position paper stresses an embedding of a personalized sentiment module *PERSEUS* in a companion. With the fact that *PERSEUS* provides a more extensive user understanding than traditional sentiment models, it is very favorable to be included by the companion given its user-oriented nature. The adaption of *PERSEUS* inside a companion can be realized, since the required information is generally present in a common situation. A multi-user scenario is especially suitable for the embedding to obtain a user-tailored companionship.

At the next stage, we evaluate the effectiveness of *PERSEUS* as an additional module in a companion system, and implement a semi-supervised transfer learning to achieve a real-time update for a better experience of communication and interaction. Furthermore, we would like to test the capacity of the number of engaged users that *PERSEUS* is able to serve without applying an extra forgetting mechanism.

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