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Emotion recognition using mobile phones☆

I. Zualkernan, F. Aloul*, S. Shapsough, A. Hesham, Y. El-Khorzaty

Department of Computer Science and Engineering, American University of Sharjah, UAE

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ABSTRACT

The availability of built-in sensors in mobile phones has enabled a host of innovative applications. One class of application deals with detecting a user's emotions. Previous applications have primarily relied on recording and displaying self-reported emotions. This paper presents an intelligent emotion detection system for mobile phones implemented as a smart keyboard that infers a user's emotional state using machine learning techniques. The system uses accelerometer readings and various aspect of typing behavior like speed and delay between letters to train a classifier to predict emotions. Naïve Bayes, J48, IBK, Multi-response linear regression and SVM were evaluated and J48 was found to be the best classifier with over 90% accuracy and precision. In addition to providing emotive feedback to individual users, the system also uses geo-tagged data to collect and display emotional states of regions or countries through a website.

1. Introduction

WITH the advent of computing came a growing dependency on smartphones that went beyond the communication purpose they were originally intended for. People today use mobile phones to carry out a range of daily tasks like shopping, ordering food, etc. In addition, mobile phones are also being used as entertainment hubs. Over time, mobile phones have increasingly become more complex to meet consumer's demands and to satisfy an ever-growing need for more computational power. An average mobile phone now comes equipped with communication modules (Bluetooth, Wi-Fi etc.), an array of sensors (accelerometers, gyroscopes, temperature sensors etc.) and significant computational power. These built-in sensors can be used to deploy unique applications that were not possible in the past.

One area where sensors can be used is to perceive a user's emotional state [1]. By capturing a user's current emotions, a device could intelligently personalize the user's experience. Such technology could support application in many domains such as social media, healthcare, etc. Social networks, such as Facebook and Twitter, would be able to respond differently to users based on their current emotional state. This could allow social networks, for example, to block a user from accessing their services, or send them help if they were in a severely distressed state. Another application in social media can be immediate feedback. A post on twitter or Facebook can be automatically flagged if the majority of viewers responded negatively to it. Another area of application is healthcare where users can keep track of their own psychological health. The application enables them to determine, for instance, sudden shifts in mood, or changes in mental health allowing a person to seek help if needed [2]. Finally, through a web service, public users could also collect demographics about the emotional

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* Corresponding author.
E-mail address: faloul@aus.edu (F. Aloul).

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state of a populace. Not only that, but medical organizations can also infer correlations between geographical conditions, context, and psychological wellbeing of individuals in that region.

Emotion recognition on various devices typically relies heavily on user input gathered in an intrusive manner [3] such as filling in surveys and/or questionnaires, or by using language processing [4] to determine the user's mood. Filling out forms is cumbersome and, for example, not likely to happen when someone is angry. Similarly, using natural language processing for emotion detection, especially on a phone, is difficult. For example, if someone were to type "lol" or "rofl" etc., the natural language processor, unless configured to recognize these short hands, would infer, falsely, that the user made a spelling mistake. Moreover, if the nature of language is taken into account and the way in which people develop words and short hand notations as new technology comes around (Google is not an English word, but is now used as a verb "let me Google that"), it becomes very difficult to design a system that can consistently detect a user's emotional state based on language alone [4].

This paper proposes to recognize the emotional state of a user by exploiting the various built-in sensors in a mobile phone. This is achieved by creating a soft-keyboard that uses sensor data to eventually determine a user's current emotion. This soft-keyboard replaces the default mobile phone keyboard and can be used with any application. The soft-keyboard connects to web-service that provides personalized statistics reflecting the emotional state of a user through time. Others can access the web service to view the average emotional profiles of populations across geographical locations.

The rest of the paper is organized as follows. The next section describes previous work in detecting emotions using mobile phones. Section III describes the design of the system including an evaluation of the machine learning algorithms used. Section IV shows the system architecture and implementation. Section V presents the conclusion and future work.

2. Background

This section provides a brief overview of previous mobile phone applications that recognize user emotions. The use of machine learning for emotion recognition is also discussed.

2.1. Detecting emotions using mobile phones

Shivhari and Saritha [5] proposed key spotting method to classify the user's emotional state based on keywords found in the user's text input. The algorithm uses a six-step process that consist of 1) Capturing User's text input, 2) Tokenizing text, 3) Identifying keywords, 4) Analyzing keywords and weighing them on a preset scale quantifying the emotion, and 5) Adding the weights to create a final classification. There are two primary limitations with this method of emotion classification. The first limitation is that this method does not account for the context in which the words occur, but merely checks for the occurrence of specific keywords. The second limitation is that the algorithm does not consider user's word choice patterns as part of the classification process. Not considering word choice pattern leads to the output being inaccurate for a wide range of users [6].

EmotionSense [7] is a stand-alone application that works by first asking users to sign up to their web service through an email account. This is done to allow data gathering for later access by the user. After sign-up, the users are taken through a brief survey that asks them questions about their emotions followed by a question that asks users to select the intensity of their current emotions on a graph. For example, the user enters the intensity of moods like "calm" or "anxious." Based on manual input, the application plots the user's mood (positive vs. negative and sleepy vs. alert, for example) on a grid. In addition, the application uses the built-in sensors like the accelerometer and the GPS to determine if the user is active or not. Level of social interaction is measured by the amount of social media used. Every week, the app unlocks a new method of detecting the user's emotion. For example, in the second week, it unlocks detection using location, then SMS patterns, and so on. Every day, the app asks the user how he feels and adds their emotion to the output grid. This is done to allow the application to develop a baseline against which it can determine the user's emotional state based on phone usage information. The user is able to check his/her statistics at any time. It should be mentioned that moods are self-reported.

T2 Mood Tracker [8] is a stand-alone application that acts like a mood diary by frequently asking the user to rate how he/she feels. This is done through the use of sliders; one for each emotion. The app then plots the emotional data over time. The application allows the user to generate reports on dimensions like anxiety, depression etc. Unlike *EmotionSense*, this application does not perform a computational analysis of the user's device usage parameters. The app only determines the user's state from the data he or she provided manually.

2.2. Using machine learning for emotion recognition

Many machine learning algorithms attempt to automate text categorization [9]. For emotion recognition, the algorithm needs to classify a user's emotional state (e.g., angry) based on the provided user input (e.g., text being typed, sensor data etc.). The primary advantage of the machine learning approach is its ability to tailor the classification based on an individual user's behavior. Supervised machine learning algorithms are used to solve this class of problems. Algorithms in this category initially require data input to be labeled with the desired output. After the initial training period, the algorithm can begin to classify new input based on the pre-classified data that was originally provided. This paper considers multiple learning algorithms; Naïve Bayes, Support Vector Machines, J48 and Regression. Each learning algorithm is briefly described next.

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