ANI: Multimodal Anxiety Detection and Management System Based on CBT

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ABSTRACT

Anxiety is a widespread mental health problem, especially for college students. College students are particularly vulnerable to anxiety because they are easily exposed to various sources of pressure, such as academic research, job hunting and interpersonal relation. Studies have shown that long-term anxiety can cause psychological problems such as depression[1].

The CBT-based anxiety management system has been a research hotspot in the field of HCI mental health in recent years[2]. CBT (Cognitive Behavior Therapy) changes the psychological problems by changing the patient's perceptions and attitudes towards people or things. In related researches, there are two kinds of anxiety management systems based on CBT, one is based on peer assistance[3] and the other is self-intervention[4]. Peer support can establish emotional connections, but inappropriate mutual assistance may have a negative impact. Self-intervention is safer and easy to operate, but it is difficult to persist without the companionship of peers.

Research shows that when facing psychological problems, many college students will not actively seek help from others because they feel ashamed and do not want to disturb others[5]. Therefore, in this work, we chose the way of self-intervention. We designed a CBT-based intelligent anxiety detection and management application, which we call ANI.

The contributions of this work are as follows:

• A new detection method for integrating online and offline data, which could improve the accuracy of detection. In addition, compared to other studies, this detection

method is automated and does not require users to actively record and fill in their anxiety situation.

• A more subdivided approach to anxiety management that systematically distinguishes between short-term anxiety and long-term anxiety. The system will choose different treatment methods according to the user's anxiety style.

Keywords: Anxiety; CBT; Mental Health; Interaction;

1 Introduction

1.1 Cognitive Behavioral Therapy

Cognitive-behavioral therapy (CBT for short) is a kind of psychotherapy orientation and a kind of talk therapy[6]. It aims to solve the emotional, behavioral and cognitive problems of disability through goal-oriented and systematic procedures. CBT is a psychosocial intervention therapy and is the most widely used evidence-based treatment principle in treating patients with mental illness [7]. CBT focuses on developing personal coping mechanisms to solve current problems, change useless patterns and emotional adjustments in cognition (eg, opinions, beliefs, attitudes).

1.2 Typical Cognitive Distortion

Just as we develop habits of behavior, we also develop habits of thought. Sometimes these habits are positive and can help us form better interpersonal relationships and achieve greater success in life[8]. Other times, our habitual thinking patterns can have devastating effects on our own mental health, relationships, and even others around us. These toxic thinking patterns usually consist of distortions to our reality, which psychologists call cognitive distortions. And we all have this problem to a different degree. But when these patterns become habitual, they cause not only distress, but also severe psychological and emotional difficulties.[9]

Here are some typical cognitive distortions，

a. All-or-nothing Thinking[10]: Think of things in a dichotomy rather than as a continuum. For example, “Failure without full success means failure. ”

b. Catastrophizing: Negatively predict the future without considering other possible outcomes. For example, “I will feel uneasy, and I will be completely useless.”
c. Labeling: Labeling someone with a fixed word, regardless of the actual conclusion. For example, “he is useless.”
d. Mental filter：Focus on negative details rather than the overall situation.

2 Related Works

After researching the existing mainstream psychological apps on the Apple Store and Google Play Store, their ideas can be summarized into the following five categories:

2.1 Emotional and physiological records

Guide users to record their emotional state or physiological information on the APP, form long-term habits and display statistical data. Emotional record forms include diary form (plain text), label form (choose the type of emotion and cause of emotion) and so on. Emotional and physiological information can be displayed in the form of charts or in innovative forms (such as the colors corresponding to emotions). Emotional and physiological records can enable users to have a clearer understanding of their physical and mental conditions, but adjustments and changes mainly depend on the user's initiative, and the APP mainly functions as a recording tool[11].

For example: Sleep record part in CBT-i Coach, checkin part in Woebot.

2.2 Muscle relaxation and meditation

Through voice or text, in conjunction with pictures and music, guide users to exercise for muscle relaxation or meditation.

For example: CBT-i Coach Meditation Relaxation.

2.3 Cognitive behavioral therapy

Based on various cognitive distortions in cognitive behavioral therapy, it guides users to discover distortions in their cognitive state and provides another idea to guide users to change their cognition[12]. Common methods include directly showing the concept of cognitive distortion in psychology in text form to guide users to reflect from certain perspectives; by asking the user's specific situation, guiding users to

write their own automatic negative thoughts, and after matching these ideas , Guide users to discover cognitive distortions and rewrite them into more accurate descriptions.

Example: What's Up , Woebot.

2.4 Chatbot assistant

In the form of chat, to some extent, the process of psychological counseling is combined with ideas such as emotional recording / cognitive behavior therapy to make the system more attractive.[13]

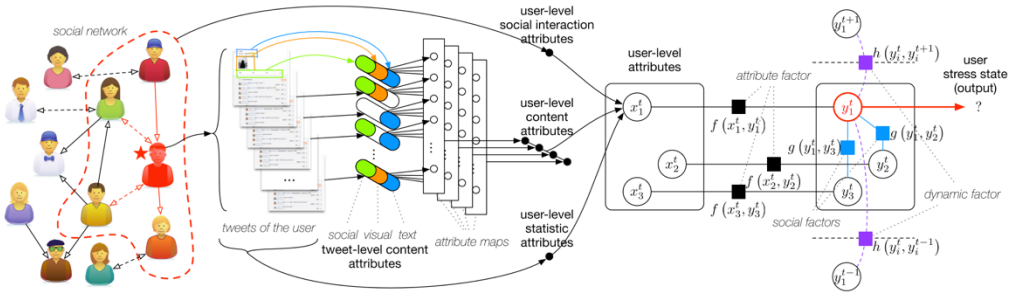
Most apps combine more than one way to implement a complete psychological help system. In addition, most apps do not provide proven professional and effective psychological adjustment methods.

3 Design: Anxiety detection model

The anxiety detection system includes two detection methods:

a. Online detection through social network data. The system trains an anxiety detection model through a large amount of microblog data. Weibo is China's largest social network with more than 500 million users. After the user binds the Weibo account on ANI, ANI can obtain the content posted by the user on Weibo, and identify the user's anxiety state.[14]
b. Offline detection through physiological data. The user's heart rate data is obtained in real time through the sports bracelet. Because of the strong correlation between anxiety level and heart rate, the user's anxiety can be derived through heart rate.[15]

3.1 Detecting anxiety with social media data



In this study, we selected Weibo data as the research object because Weibo is the largest social platform in China.

3.1.1 Model designe

a. Extracting Tweet-level attributes

b. Extracting User-level attributes

c. Detect user anxiety through User-level attributes

3.1.2 Feature design

a. Tweet-level attributes

Tweet-level attributes could characterize the information contained in a single Weibo.

Category	**Short Name**	#	**Description**
Linguistic	Positive & Negative Emotion Words	2	Number of positive and negative emotion words
	Positive & Negative Emoticons	2	Number of popular positive and negative emoticons
	Punctuation Marks & Associated Emotion Words	4	To signify the intensity of emotion four typical punctuation marks (’!’, ’?’, ’...’, ’.’) are considered.
	Degree Adverbs & Associated Emotion Words	2	In examples “{I feel a little bit sad}” and “{I feel terribly sad}” , ’sad’ expresses different negative feelings. We use 1-3 to represent neutral, moderate, and severe degree of positive emotions, and the minus to represent the negative ones.
Social	Social Attention	3	Number of comments, retweets, and likes

b. User-level attributes

User-level attributes represent a user's social information for one week, and are mainly divided into the following three parts: Posting Behavior, Social Interaction, and content. Content is extracted from the Tweet-level attributes of the user's Weibo via a CNN through a CNN.

Category	**Short Name**		**#**	**Description**
Posting Behavior	Social Engagement		3	The numbers of @-mentions, @-retweets, and @-replies in weekly tweet postings, indicating one's social interaction activeness with friends.
	Tweeting time		24	The numbers of tweets posted in hours with a 24- dimensional vector.
	Tweeting type		4	Categorize users' tweets into mainly four types based on general categories of social media platforms: (1) Image tweets (tweets containing images); (2) Original tweets (tweets that are originally authored and posted by the user); (3) Information query tweets (tweets that ask questions or ask for help); (4) Information sharing tweets (tweets that contain outside hyperlinks). We use a 4-dimensional vector of the numbers of tweets in the above 4 types respectively to quantify the tweeting type attribute.
	Tweeting linguistic style		10	Adopt 10 categories from LIWC that are related to daily life, social events, e.g., personal pronouns, home, work, money, religion, death, health, ingestion, friends, and family. We extract words from users' weekly tweet postings, and use a 10-dimensional vector of numbers of words in the 10 categories
Social Interaction	Content Style	Words	10	A 10-dimensional integer vector, with each value representing the number of words from social interaction content of users weekly tweet postings in each word category from LIWC;
		Emoticons	2	A 2-dimensional integer vector with each value representing the number of positive and negative emoticons (e.g., and) in tweets.
	Social Influenc	Stressed Neighbor Count	1	The number of the user's stressed neighbors.

		Strong-tie Count	1	The number of stressed neighbors with strong tie.
		Weak-tie Count	1	The number of stressed neighbors with weak tie.
		Follower Count	1	The number of the user's followers.
		Fans Count	1	The number of the user's fans.
	Social Structure		8	Representing the structure distribution of the user's interacted friends, where each element refers to the existence of the corresponding structure

3.1.3 Detection method

a. Factor Graph Model (PFG)

b. Logistic Regression (LRC)

c. Support Vector Machine (SVM)

d. Random Forest (RF)

e. Gradient Boosted Decision Tree (GBDT)

f. Deep Neural Network (DNN)

3.2 Detecting anxiety with physiological data

3.2.1 Detection Indicator

Mean RR(ms); Mean pNN50(%)

3.2.2 Detection method

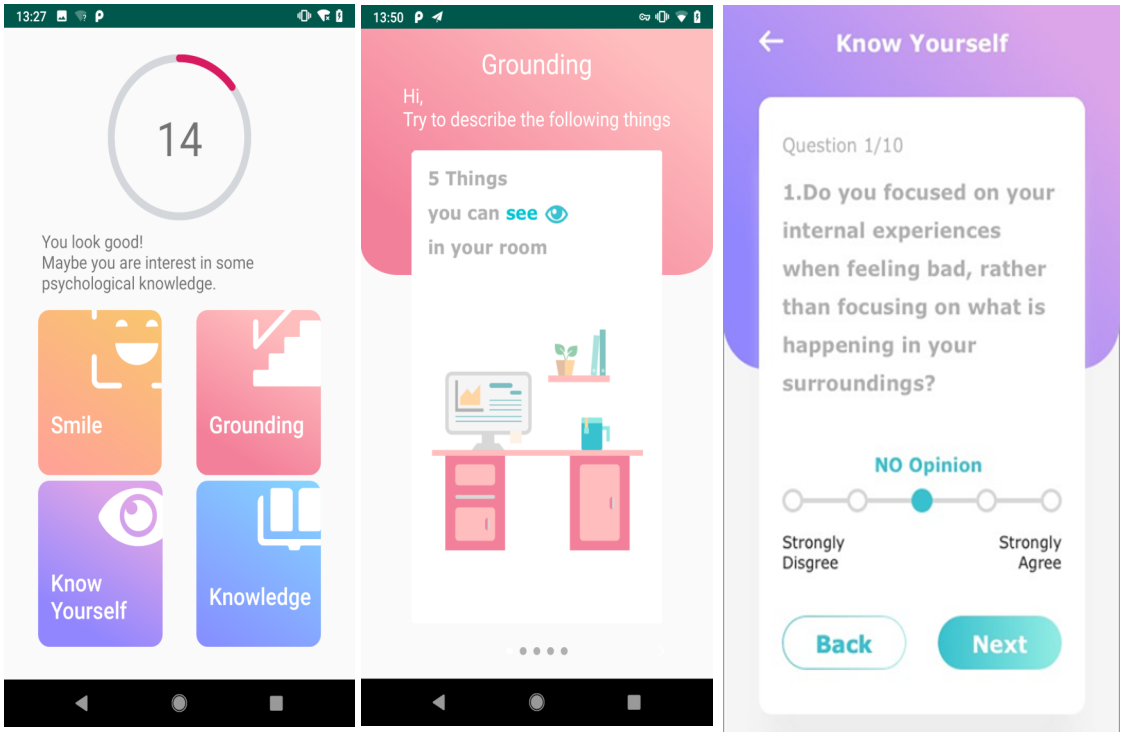
	Rest	**Mental task**
Mean RR(ms)	0.816 (±0.13)	0.790 (±0.13)
Mean pNN50(%)	18.6 (±14.8)	14.2(±12.6)

3.3 Demo design

The anxiety management system includes a relaxation system and a management system.

a. When the user feels a serious anxiety, the relaxation system will calm down the user through the landing technique and get out of the anxiety state, so as to carry out the later cognitive training.

b. The management system focuses on helping users who are anxious due to cognitive distortions, primarily for long-term anxiety. The system can identifies the



user's cognitive distortions through psychometric scales and dialogues, and then introduces similar CBT treatment cases. The system relies on repeated cognitive training to change the cognitive distortion of the user, thereby relieving anxiety.

4 Experiment

4.1 Research objectives

a. Use a large amount of user Weibo data (online data) to explore how to use deep models to detect user anxiety status (mainly detecting whether there is long-term anxiety) and the degree of anxiety

b. Detect user anxiety status (mainly short-term acute anxiety and reference for long-term anxiety detection) and anxiety level through real-time physiological data (mainly heart rate and step count, offline data)

c. Analyze the current user's anxiety status and anxiety level in combination with online and offline data of users

d. In the form of an Android APP, comprehensively integrate the test results, use psychological knowledge to help users reduce anxiety levels, and introduce the CBT treatment process specifically to users, in the hope of helping long-term anxious users

to change cognitive distortions

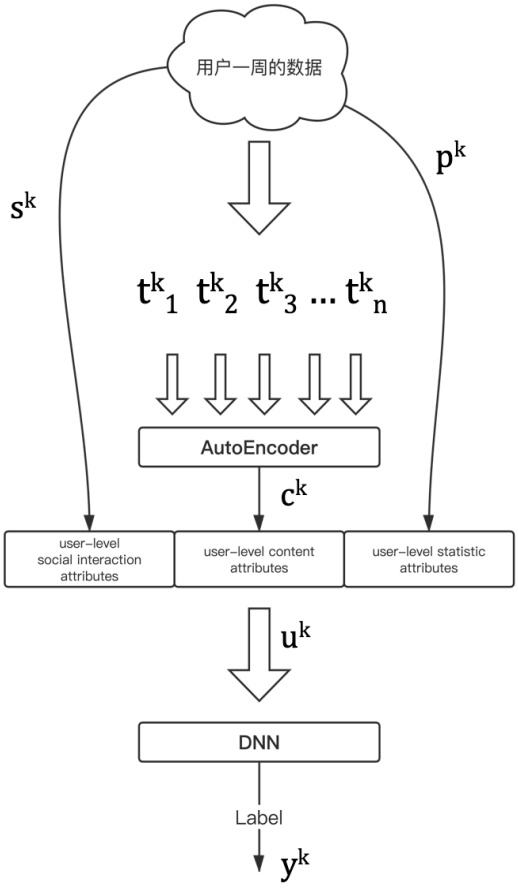
4.2 Online detection

Given the Weibo data published by a user over a period of time $blog_i^k$ $(0 \leq i < n)$, tags need to be given to indicate whether the user has anxiety $y_k = 0/1$. After research, we finally referred to "Detecting Stress Based on Social Interactions in Social Networks".

The main idea of the algorithm is:

a. Feature extraction from user's Weibo via human prior knowledge

b. Map high-dimensional features to low-dimensional labels through neural networks



Model Structure

4.3 Offline detection

The normal resting heart rate in humans is 60-80bpm, and usually healthy people have a lower heart rate. A resting heart rate exceeding 100bpm is called sinus tachycardia. Previous studies have shown that cardiovascular disease mortality

significantly increases when resting heart rate exceeds 90bpm, so we choose 90bpm as the resting heart rate threshold.

4.4 Experiment record

In order to test the system effect, we invited 20 college students with anxiety symptoms to participate in the experiment for four weeks. Participants were asked to wear bracelets in real time, and they had to record their feelings on Weibo. Participants' anxiety levels were measured weekly using a psychology scale. The GAT7 scale was used in the experiment, which is a commonly used measure of anxiety in psychology.

Experimental results:

- The average anxiety index of the participants before the experiment was 9.05, and the average anxiety index decreased to 8.50 after the experiment. The experimental result proves that ANI effectively alleviates the anxiety of the participants.
- User interview results show that, firstly, participants like the function of active reminders because they did not know what to do when they felt anxious, and this feature can remind them to open ANI. Secondly, they feel that the landing function is very effective and can quickly calm down from anxiety. Thirdly, they think CBT is helpful in changing cognition, but they don't think the system can accurately identify their cognitive distortions.

5 Conclusion

To help college students manage anxiety, we designed a CBT-based self-intervention system, ANI. ANI can detect the user's anxiety state through social network data and physiological data, distinguish the type of anxiety the user is in, and provide corresponding help. The experimental results show that ANI can effectively alleviate the anxiety of college students. In future work, we will optimize the recognition accuracy of ANI for cognitive distortion types and the fun of interactive methods.

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