

Towards Automated Detection and Regulation of Affective States During Academic Writing

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Abstract. This project focuses on developing methods to automatically detect and respond to emotions that students experience while developing writing proficiency with computerized environments. We describe progress that we have already made toward detecting affect during writing using keystroke analysis, stable traits, and task appraisals. We were able to distinguish boredom from engagement with an accuracy of 38% above random guessing. Our next goal is to improve the accuracy of our classifier. We plan to accomplish this through an exploration of higher level features such as sequences of character types. Ultimately we hope to develop a system capable of both detecting affect and influencing affect through interventions and experimentally testing this system.

Keywords: affect, keystroke, writing, boredom, engagement.

1 Introduction

Writing is a task that is performed in a variety of daily situations. Writing makes up a large portion of human communication and is increasingly being considered an important 21st century skill [1]. With this increased importance comes a need to not only understand the components of proficient writing, but also a desire to bolster the abilities of students whose writing proficiency may be lacking. This is especially pressing in light of the possibility that the average student possesses inadequate writing skills. A 2011 National Assessment of Educational Progress report declared that only 27% of 12th graders in the U.S. were considered to be “proficient” writers, which is a lower percentage of 12th graders than what was reported in 2007 [2].

In order to improve writing proficiency, it may be beneficial to delve deeper into the psychological processes involved in writing. Until now, most of the research on writing has focused on the cognitive aspects of writing, such as the classic cognitive process theory developed by Flower and Hayes or the more recent functional dynamic approach to the writing process developed by Rijlaarsdam and Bergh [3, 4]. Researchers have also proposed some automated systems to help students develop writing proficiency, such as Summary Street and Writing Pal [5, 6]. To date, however, the emphasis of research and technology is on the cognitive processes involved in writing. This might be insufficient because emerging evidence suggests that affective states continually arise and play an important role in the process of writing [7].

For example, D’Mello and Mills tracked the emotions of writers in two studies and found that boredom, engagement/flow, anxiety, frustration, and happiness were the most frequent affective states experienced and some of these states were correlated with writing outcomes (quality of a written essay). Given this observation, we hypothesize that a system that can detect and respond to affect could have a significant impact on writing quality by helping writers upregulate positive affective states (e.g., engagement, curiosity) and downregulate negative states (e.g., boredom, anxiety). Developing and validating such an affect-sensitive system is the focus of the proposed project.

2 Previous Research (Affect Detection)

An affect-sensitive writing environment must first detect affect before it can respond to affect. Over the last decade, affect detection has progressed via a number of modalities including facial expression, speech, and physiology (see [8] for a review). Each modality has associated strengths and weaknesses, as well as certain situations in which they are more or less applicable. However, they all require physical sensors and this causes scalability issues. Taking a different approach, we focus on detecting a writer’s affective states via keystroke analysis, a technique that is attractive for several reasons. First, collecting data is relatively unobtrusive. All that is needed is installed software to collect keystrokes and a keyboard. Second, keystroke analysis is scalable since every general purpose computer includes a keyboard. Third, the object of writing is to produce text, thereby making keystroke analysis ideal for affect detection in writing contexts. Finally, keystrokes are generated by a number of other tasks so any methods we develop could potentially be used in other domains as well.

Our first project involved detecting affect through keystroke analysis while participants completed an essay writing task. Forty-four participants typed three essays on a computer interface which logged each keystroke along with timing information. Immediately after the writing session, participants watched a video recording of their face and a screen capture video and provided self-judgments of their affective states at 15 second intervals [7].

We calculated 12 features (e.g. verbosity, smallest time difference between keystrokes) for each 15 second self-judgment interval from the keystroke logs and combined them with stable traits such as ACT scores and task appraisals such as subjects’ interest in the writing task. We only used data from the boredom, engagement, or neutral, classes as these states comprised the majority of the affect labels (72.9%). We built a large number of models in which we varied classifiers, the affective states being discriminated, data manipulations such as downsampling and standardization, and chosen features. Our results indicated that the models built to distinguish engagement from boredom using task appraisals, stable traits, and both keystroke and timing features performed the best, with a kappa value of 0.374 and an accuracy of 87.0%. The models built to distinguish all three emotions from one another using task appraisals, stable traits, and both keystroke and timing features performed somewhat worse, with a kappa value of 0.171 and an accuracy of 56.3% [9].

3 Future Work

Our research is proceeding along two avenues: improving affect detection and designing affect-sensitive interventions. These are briefly discussed below.

3.1 Improving Affect Detection

Our immediate goal is to improve the classification rate of our automated affect detection models, with an overarching goal of establishing just how effective keystroke analysis can be for determining affect. We have been attempting to do this by analyzing sequences of keystroke events and using these as features. Our aim is to identify sequences of writing, editing, or varying lengths of pauses, and determine if we can use these higher level events as features. We are also working on improving affect detection by examining the broader context of essay composition. As of now, we only analyze each 15 second interval of data in isolation, but a further step that might prove beneficial is to implement features that depend on not only the current interval, but all the previous intervals as well. Another line of work involves exploring the generalizability of our affect detectors by performing cross-validation experiments across different essay topics and student characteristics. A limitation of our previous experiment was the narrow range of emotions that we focused on. During this stage we will expand the scope of our detection to include more affective states.

3.2 Designing Affect-Sensitive Interventions

The next step is to develop interventions to regulate affect. Appropriate interventions would transition a user into an affective state that is most conducive to their current writing task. Interventions will be selected from the literature along with new ones that we wish to try. Examples of interventions would be supplying writing advice or supportive statements when a participant is feeling confused or frustrated. We will then evaluate their ability to influence the affective state of the writer via formative testing. Each writer will perform one of the writing tasks used in the previous studies. Our system will attempt to detect certain affective states based on a running stream of the user’s keystrokes, and once a target affective state is detected it will administer one of the interventions. If our system then detects a different affective state and overall writing outcomes improve, the intervention will be deemed successful.

3.3 Experimentally Testing Interventions

The third step is to compare a system that incorporates affect detection and intervention to a system that detects but does not respond to affect. Participants would be randomly assigned to one of two groups. Participants in the first group will complete two writing tasks without attempted intervention, while the second group will complete two writing tasks with a system that *does* attempt interventions. Each essay will be scored and compared to evaluate the effect of interventions on writing proficiency.

4 Conclusions

We have described a research project that aims at creating a scalable system that can detect and intervene to regulate a writer's affective state. We focus on affect detection during writing because it is a convenient domain to explore and because of the significant role that affect has been shown to have on writing. However, it is important to note that our methods may not be restricted to a writing context. Affect detection in other domains that involve tasks which generate keystrokes would conceivably also benefit from our research. It is our hope that our methods can be adopted for use in other domains as well. In addition to the important engineering goal of developing our proposed, another goal is that our research activities influence the cognitive process theory of writing to incorporate affect. If affect does play a part in the writing process, as some evidence shows, then hopefully the results of this research will help inform a new theory of writing, an affective-cognitive process theory of writing.

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