Presentations

SESSION 1

HUMAN ERROR ON CODE INSPECTION AND DEVELOPMENT – COMPUTER SCIENCE PERSPECTIVE
(CHAIR: HAYTHAM HIJAZI)

Henrique Madeira

Biofeedback augmented software engineering: a new paradigm to improve software quality

Abstract: Although the human error is the root cause of software bugs, paradoxically the software development approaches, not even the most recent agile methods, do not consider the actual cognitive state of the individual programmers during coding, inspection or testing activities, as a direct input of quality control in the software development process. A developer could be attentive, highly engaged, and apparently mastering the task at hand, but the same programmer could be exhausted some hours later or on a different day. The reality today is that code production, code reviews, testing and all other activities of software development largely ignore this important quality element: the direct information on the human element. Even if the programmer is fresh as a daisy, he/she could spend a very high mental effort writing or inspecting a given code passage (because it is too complex for him/her), or he/she could be distracted, interrupted, or simply overloaded or stressed by contextual/environmental information. All these cognitive states (high mental effort, stress level, attention shifts, cognitive overload, mental fatigue) have been linked to error prone scenarios, as established by cognitive human error models, and represent in fact the root causes of software defects. In the BASE project we propose a paradigm shift in software development using nonintrusive programmers' biofeedback to incorporate the developer's cognitive state as a central quality element of the software development process. This presentation restates the key elements of the BASE project and discusses possible avenues for future research that are now quite visible, largely because of the results obtained by the project in the first two and a half years.

Fuqun Huang

How Programmers Make Errors? --A Pilot Experimental Study

Abstract: As the primary cause of software defects, human error is the key to understanding and perhaps to predicting and avoiding them. However, little research has been done to understand the mechanisms of how software defects are caused by programmers' cognitive errors from psychological perspective. Dr. Huang will present some interesting findings obtained in her interdisciplinary experiment, which is based on programming and psychological theories.

João Durães

Trusting code inspections - An inspection on the inspector's effectiveness

Abstract: Code inspections are currently used by main software development companies to spot problems in the code. The effectiveness of this practice relies on the effectiveness of the inspectors themselves, which is dependent not only on the inspector expertise but also on other factors hard to predict. In this presentation we analyse some findings concerning an experimental assessment of the inspection quality and discuss directions on how to estimate said quality.

SESSION 2

HUMAN ERROR IN THE NEUROSCIENCES PERSPECTIVE - FMRI AND FNIRS (CHAIR: JOÃO CASTELHANO)

Miguel Castelo Branco

The neural error monitoring system and its contribution to programming tasks

Abstract: Software programming is a complex and relatively recent human activity, involving the integration of mathematical, recursive thinking and language processing. We hypothesize that calculus and reading brain networks provide distinctly weighted contributions in which concerns software errors and the processing of error identification. Based on a metaanalysis and review of the emerging literature we provide a theoretical framework for the novel research field addressing the neural underpinnings of reading and math underlying program understanding. In this framework, we present also evidence for a role of the insula, which is a pivotal hub within the salience network, in error monitoring tasks, in particular during bug monitoring. Finally, we also discuss recent evidence for the role of the error monitoring system in different cognitive components of computer programming and its relation to other brain networks.

Marco Simões

Approximating BOLD-fMRI signals from simultaneous EEG data: promises, pitfalls and relevance for biofeedback applications

Abstract: The recording of BOLD signals through fMRI represents the method of choice for measuring activity of localized brain areas. Thus, BOLD-fMRI can serve as ground-truth for biofeedback applications. However, its direct application in biofeedback systems is hampered by the economical and logistical constraints of fMRI settings, which may be however surpassed by transferring it to EEG setups, due to their low cost and portability. One of the major challenges of this procedure is then to reconstruct the BOLD-fMRI signal measured at regions of interests using only EEG signals. In this talk we address the promises, pitfalls and relevance of this approach for the development of real-life biofeedback solutions.

João Castelhano

The neural correlates of programming skills: fMRI preliminary results

Abstract: The neural underpinnings of source code programming skills are a matter of increasing interest in the last few years. We performed a fMRI experiment to understand those networks and help to elucidate the neurophysiological reasons why programming still leed to code with errors (Bugs). The present fMRI study directly addressed error monitoring during source code comprehension, expert bug detection and decision-making during different code complexity trials. Here we present the preliminary results.

Speaker: Caterina Amendola

Title: Time Domain Functional NIRS for human brain mapping

Abstract: N/A

SESSION 3

COGNITIVE LOAD AND CODE COMPREHENSION ASSESSMENT USING NON-INVASIVE AND NON-INTRUSIVE BIO-SIGNALS (CHAIR: JULIO MEDEIROS)

Alessandra Calcagno

EEG analysis during a software development task

Abstract: This work focuses on the analysis of EEG signals acquired on experienced programmers during a software development task with the aim of exploring the main neurological mechanisms (i.e., involved brain areas, rhythms and network interactions) supporting such a complex task. To do this, the power spectral density at 29 EEG channels in standard Delta, Theta, Alpha and Beta bands has been computed. Our data show on average a significant increase in Theta power and a decrease in the Alpha power with respect to a baseline condition. Theta power increases mainly in the frontal and parieto-occipital regions, while Alpha activity shows a diffused decrease. Moreover, power content in the Theta band tends to decrease throughout the programming task, suggesting an increase of mental fatigue or a decrease of attention level. Effective connectivity studies also suggest that in the Theta rhythm the frontal region of the brain acts as an information sink, while the occipital region as a source. The opposite direction of information flow is observed in the alpha band.

Haytham Hijazi

Cognitive Load Measurement in Code Comprehension Using Non-Invasive Biosensors, Eye Tracker, And AI

Abstract: Difficulties in code comprehension would induce variations in cognitive load. The changes in cognitive load can be characterized by the modulation of the Autonomic Nervous System (ANS), such as the Heart Rate Variability (HRV) or the pupil diameter change. These changes can be captured by widely available non-invasive biosensors (e.g., Electrocardiogram) in real-time. However, due to the non-specificity of such biomarkers to cognitive load assessment., the use of Artificial Intelligence has become a good potential in optimizing the cognitive load classification (i.e., high, low). In this talk, the use of pupillography and Heart Rate Variability biomarkers in real-time code comprehension assessment is explored. Moreover, the use of eye tracker as a localizer of the code regions that caused comprehension difficulties is discussed. Finally, different AI techniques are explored which were used to classify cognitive load associated with comprehending regions of code. The presented study showed very good potential of using biosensors, eye tracker and AI to capture the code comprehension difficulty in a timely manner and a reasonable spatial resolution with an accuracy of 83.00% ± 0.75.

Júlio Medeiros

Establishing EEG as ground truth for the assessment of cognitive state: Towards a new software engineering paradigm using biofeedback

Abstract: Current Software Engineering approaches do not consider the human factor in an individual perspective. Cognitive human error and recent cognitive taxonomy on human error causes of software defects support the intuitive idea that, for instance, mental overload, attention slips and working memory overload are important human causes for software bugs. In this workshop we will present our preliminary results from the analysis of the EEG from software programmers while they perform a specific software task (code inspection and bug detection). Our hypothesis in this first part of the work is to establish the EEG as a reliable ground truth for the assessment of the cognitive states of the software programmers during such software tasks. Therefore, we intend to establish potential EEG biomarkers, associated with human error making and error discovery, that can be used as a reference to validate other physiological measures (from the ANS-related signals). These ANS-related signals can be recorded using wearable and nonintrusive devices (e.g., ECG and Eye-tracking with Pupillography) that can be used in daily life conditions of a software programmer. The goal is to use information recorded from those sensors to capture the relevant cognitive state of individual developers during the software developments process and use such data for the final goal of the BASE project regarding the development of a bug prediction risk model.