VCU College of Engineering

CS 25-315

Emotion Recognition in Developer Meetings Using Advanced AI

Project Proposal

Prepared for

Kostadin Damevski

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By

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Under the supervision of

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10/5/2024

Executive Summary

The shift towards remote work has significantly transformed the landscape of the software development industry, presenting unique challenges that impact cognitive performance and overall well-being. This project, sponsored by Kostadin Damevski of the VCU College of Engineering, addresses the pressing need for a real-time emotion recognition tool designed specifically for software developers during virtual meetings. The cognitive load and fatigue experienced by developers have been exacerbated by back-to-back meetings, minimal physical movement, and reduced non-verbal communication, all of which can hinder productivity and mental health.

As remote work becomes increasingly prevalent, the implications of these challenges extend beyond individual developers, impacting organizations and the global workforce. The transition to virtual environments, accelerated by the COVID-19 pandemic, has underscored the necessity for innovative solutions that mitigate the physical and mental toll of prolonged remote work. Without effective intervention, the resulting cognitive overload can lead to reduced work output, increased errors, and heightened mental health issues, including burnout and stress.

The primary stakeholders of this project include software developers, organizations utilizing remote work models, and the broader remote workforce. The project aims to harness advancements in **natural language processing (NLP)** to enhance emotional awareness and collaboration among remote teams. By integrating emotion recognition capabilities, the tool will provide actionable insights into emotional dynamics during meetings, fostering improved communication and reducing cognitive load.

Conducted in the Software Improvement (SWIM) Lab at VCU, this project builds upon existing research in remote work and emotion recognition, which has traditionally focused on static environments. Our approach focuses on real-time emotion detection during virtual meetings, utilizing multiple communication modalities, such as voice tone, facial expressions, and text sentiment, to enhance the understanding of emotional interactions in dynamic settings.

Key objectives of the project include:

1. Developing an advanced AI system for accurate emotion measurement during meetings.
2. Providing insights into team emotional dynamics to enhance collaboration.
3. Contributing to the mental well-being of software developers through emotional awareness.
4. Delivering emotional intelligence data to inform project management decisions.

The design will focus on real-time processing capabilities, seamless integration with existing virtual meeting platforms, non-intrusive feedback mechanisms, user data privacy compliance, and minimization of cognitive load. We aim to achieve a high accuracy rate in emotion detection and maintain affordability for small businesses and freelance developers.

To ensure adherence to industry standards, the project will comply with relevant regulations, including GDPR and HIPAA, and align with best practices in user interface design. The success of this project will not only advance the field of software engineering but also promote healthier and more productive remote work environments for software developers worldwide.

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Section A. Problem Statement

In recent years, the shift towards remote work has introduced new challenges for employees, particularly those in the software development industry. One unmet engineering need in this domain is a real-time emotion recognition tool designed to provide better insights into the impact of remote work meetings on software developers. The cognitive load and fatigue experienced by developers in virtual settings are often greater than in-person work environments, which may be attributed to various factors such as back-to-back meetings, minimal physical movement, weakened non-verbal communication, and prolonged screen exposure.

Software developers working remotely are the primary group affected by this problem. Remote work, though convenient, brings a unique set of challenges that can adversely impact developers' cognitive performance and overall well-being. The increased reliance on virtual meetings reduces opportunities for physical movement and personal interaction, while diminished non-verbal cues make communication more challenging. These factors, combined with the necessity to concentrate on a screen for extended periods, contribute to mental fatigue and diminished productivity.

This issue is not confined to software developers alone; it has become a global concern. The COVID-19 pandemic catalyzed a rapid shift towards remote work for millions of people worldwide. Advances in business communication platforms have made this transition sustainable, but it also underscores the growing need for tools that address the physical and mental toll of prolonged remote working conditions.

The health and well-being of remote employees are at risk, leading to potential costs on several fronts. Economically, reduced productivity due to fatigue and cognitive overload may lead to decreased work output and increased errors. Societally, the mental health impact of remote work could contribute to burnout, stress, and long-term health consequences. There may also be safety implications if such fatigue affects decision-making in critical areas of software development. Addressing this problem is essential for maintaining a healthy and productive remote workforce.

The project is sponsored by Kostadin Damevski, a faculty member of the VCU College of Engineering. The primary stakeholders include software developers, the broader remote workforce, and companies relying on virtual teams to maintain productivity in a remote-first or hybrid work environment.

This project falls under the broader field of software engineering and natural language processing (NLP), with a specific focus on how NLP techniques can be applied to the software development lifecycle. By developing a real-time emotion recognition tool, the project aims to advance the understanding of emotional and cognitive dynamics in virtual meetings, contributing to the broader research on improving productivity and well-being in remote work settings.

The work is being conducted in the Software Improvement (SWIM) Lab at the VCU College of Engineering, where research is centered on software maintenance and evolution. The

SWIM Lab’s expertise in software improvement provides a foundation for exploring how emotion recognition can aid developers in managing the mental demands of remote collaboration.

Historically, remote work has been a subject of research, especially in the context of telecommuting, and more recently during the COVID-19 pandemic. Several studies have explored the psychological and cognitive impacts of remote work, including the challenges of virtual communication and the potential for increased stress and burnout. Prior solutions in the field of emotion recognition have focused primarily on detecting emotions in static or well-controlled environments, such as facial expression analysis or sentiment analysis from text. However, these approaches often fall short when applied to dynamic, real-time scenarios, particularly in a work setting.

This project seeks to improve on these solutions by focusing specifically on real-time recognition during virtual meetings, where multiple communication modalities (e.g., voice, text, facial expressions) interact. By integrating emotion detection with insights into developers' cognitive load, this tool aims to provide actionable feedback that can improve meeting structures and reduce fatigue, ultimately enhancing productivity.

Section B. Engineering Design Requirements

B.1 Project Goals (i.e. Client Needs)

The overall goals of this Emotion Recognition in Developer Meetings project stem from the need to understand and improve the emotional dynamics within software development teams. These goals are focused on enhancing productivity, collaboration, and mental health in the industry. The key project goals include:

- Developing an advanced AI system for accurately measuring and interpreting emotions in software developer meetings using multiple modalities.
- Providing insights into team emotional dynamics that can lead to improved communication and collaboration.
- Contributing to the overall mental health and well-being of software development professionals by promoting emotional awareness.
- Enhancing project management by providing emotional intelligence data that can inform decision-making and team structure.

B.2 Design Objectives

1. The design will provide real-time emotion detection during virtual meetings.
   - Specific: Focuses on detecting emotions based on various inputs like voice tone, facial expressions, and text sentiment.
   - Measurable: Success will be measured by the accuracy of emotion detection and user feedback.
   - Achievable: Achievable with current technology in natural language processing and emotion recognition.
   - Realistic: Given the scope of existing tools, real-time processing is realistic with optimized algorithms and hardware.
   - Time-bound: Prototype to be developed within 6 months, with user testing completed in the following 2 months.

2. The design will integrate seamlessly with existing virtual meeting platforms.
   - Specific: Integration with platforms like Zoom, Microsoft Teams, and Slack.
   - Measurable: Measured by the tool's ability to function within these platforms without disruption.
   - Achievable: APIs for these platforms are publicly available, making integration feasible.
   - Realistic: Realistic with proper research into each platform's API.
   - Time-bound: Integration complete within 3 months post-prototype.

3. The design will deliver feedback to users without interrupting the meeting flow.
   - Specific: Emotional feedback will be provided non-intrusively, using visual or auditory cues.
   - Measurable: Measured by user surveys evaluating the feedback mechanism's unobtrusiveness.

- Achievable: Feedback mechanisms like notifications or dashboards are achievable within the project's scope.
- Realistic: Aligns with user interface design principles.
- Time-bound: Feedback mechanism testing complete within 1 month of integration.

4. The design will ensure user data privacy and comply with data protection regulations.
   - Specific: Compliance with GDPR, HIPAA, and other data security regulations.
   - Measurable: Measured by successful completion of a privacy audit.
   - Achievable: Achievable by implementing encryption and secure data handling procedures.
   - Realistic: Data privacy is a standard practice in software development.
   - Time-bound: Privacy features implemented and audited within 4 months.

5. The design will minimize cognitive load for users during meetings.
   - Specific: Focuses on providing concise, actionable insights without overwhelming the user.
   - Measurable: Cognitive load reduction measured by user feedback and performance tests.
   - Achievable: Achievable through careful interface design and testing.
   - Realistic: User experience research will guide the development of this feature.
   - Time-bound: Usability testing complete within 2 months after initial deployment.

B.3 Design Specifications and Constraints

1. Real-time Processing Capability (Functional Constraint)
   - Objective: The design will provide real-time emotion detection during virtual meetings.
   - Specification: The system must process input data (voice, video, text) with a latency of no more than 1 second from data capture to feedback display.
   - Testable Metric: Latency must be measured in various environments (local, cloud-based) and must stay within the maximum acceptable delay of 1 second.

2. Integration with Existing Platforms (Interoperability Constraint)
   - Objective: The design will integrate seamlessly with existing virtual meeting platforms.
   - Specification: The tool must be compatible with at least 3 major platforms (e.g., Zoom, Microsoft Teams, Slack).
   - Testable Metric: Successful connection and functionality within APIs provided by these platforms must be demonstrated, with minimal disruption to core platform features.

3. Accuracy of Emotion Detection (Functional Constraint)
   - Objective: The design will provide accurate emotion detection.
   - Specification: The system must achieve an accuracy rate of at least 85% in detecting emotions across different user profiles (age, gender, cultural backgrounds).
   - Testable Metric: Emotion detection accuracy will be evaluated through user trials and compared to a benchmark dataset of labeled emotional states.

4. Privacy Compliance (Legal and Data Constraint)

- Objective: The design will ensure user data privacy and comply with data protection regulations.
- Specification: The design must meet GDPR and HIPAA standards, including encryption of data during transmission and storage.
- Testable Metric: Compliance with regulations will be tested through privacy audits, and encryption effectiveness will be validated using industry-standard tools.

5. Cognitive Load Reduction (Usability Constraint)
   - Objective: The design will minimize cognitive load for users during meetings.
   - Specification: The emotion recognition feedback must occupy no more than 10% of the screen at any given time and should be presented in a non-distracting manner (e.g., through subtle visual cues or minimal text).
   - Testable Metric: Usability tests will measure user feedback on distraction levels and confirm screen area usage.

6. Hardware Compatibility (Hardware Constraint)
   - Objective: The design will function on commonly used hardware setups.
   - Specification: The software must operate on devices with at least 8 GB RAM, Intel i5 or equivalent CPU, and standard integrated webcam and microphone.
   - Testable Metric: System performance will be evaluated on different hardware configurations, ensuring consistent performance across various setups.

7. Cost-effectiveness (Cost Constraint)
   - Objective: The design must be affordable for target users (small businesses and freelance software developers).
   - Specification: The software should not exceed a $100 annual subscription fee per user.
   - Testable Metric: The cost of development, licensing, and support will be compared to similar tools on the market, ensuring the price stays within this range.

8. Data Collection and Processing Constraints (Data Constraint)
   - Objective: The design will operate within constraints on data collection and processing.
   - Specification: The tool must handle at most 1 GB of data per hour for video and audio processing.
   - Testable Metric: Data usage will be tracked during testing sessions to ensure it remains within this limit, with a focus on optimizing data compression and processing efficiency.

9. Maintainability (Maintainability Constraint)
   - Objective: The design will be maintainable with minimal effort.
   - Specification: The system must require no more than one major update per quarter, and each update must take no more than 2 hours to apply.
   - Testable Metric: Maintenance and update cycles will be tracked and evaluated against the timeline to ensure adherence to these constraints.

These specifications and constraints provide clear, measurable goals for ensuring the design meets its objectives while staying within realistic and testable limits.

B.4 Codes and Standards

Codes relevant to our design:

1. General Data Protection Regulation (GDPR) – EU Regulation 2016/679
   - Relevance: This code governs data privacy and security for any systems processing the personal data of EU citizens. Since the tool will collect and process sensitive user data (emotions, facial expressions, speech), compliance with GDPR is essential.
   - Key Constraints: Data processing must be transparent, secure, and with the user's consent. Data should be anonymized or encrypted, and users must have the right to access, rectify, or delete their data.

2. Health Insurance Portability and Accountability Act (HIPAA) – U.S. Public Law 104-191
   - Relevance: If the tool is used by health-related entities or individuals, HIPAA may apply, especially if it collects any data related to health metrics or well-being.
   - Key Constraints: The design must ensure the confidentiality and integrity of health-related information, and encryption must be used when transmitting sensitive data over networks.

3. Occupational Safety and Health Administration (OSHA) Standard 29 CFR 1910
   - Relevance: This code relates to workplace safety, which could be relevant if the emotion recognition tool is used in workplace settings to assess worker well-being and stress.
   - Key Constraints: The design must not contribute to excessive screen time or cognitive overload, which could negatively impact the user's health and safety.

Standards relevant to our design:

1. IEEE Standard 802.11 – Wireless LAN Standards
   - Relevance: This standard governs wireless communications, ensuring the tool can efficiently transmit data over wireless networks (Wi-Fi) used in remote work setups.
   - Key Constraints: The tool must be able to operate over standard Wi-Fi networks with minimal latency to ensure real-time processing. Communication protocols must ensure reliable and secure data transmission.

2. ISO/IEC 27001 – Information Security Management
   - Relevance: This standard provides requirements for managing sensitive information securely, making it crucial for the tool's data handling procedures.
   - Key Constraints: The tool must have controls in place for confidentiality, integrity, and availability of data. This includes encryption, access control, and regular security audits to ensure compliance with this standard.

3. IEEE Standard 1789-2015 – Recommended Practices for Modulating Current in High-Brightness LEDs

- Relevance: If the design involves a user interface with LED-based notifications or feedback, this standard addresses health concerns related to the flicker of LED lighting.
- Key Constraints: Ensure any visual feedback from the tool's user interface avoids flicker frequencies that could lead to discomfort, fatigue, or cognitive strain for users.

4. ISO 9241-210:2019 – Ergonomics of Human-System Interaction
   - Relevance: This standard applies to the user interface and user experience design, ensuring that the tool's interaction with users is ergonomic and minimizes cognitive load.
   - Key Constraints: The interface must be intuitive and not detract from the main tasks in remote work meetings. Visual feedback should be designed to be clear and non-intrusive.

Section C. Scope of Work

C.1 Deliverables

Academic Deliverables

- Team contract
- Project proposal
- Preliminary design report
- Fall poster
- Final design report
- Capstone EXPO poster

Project Deliverables

- Experiment results comparing the accuracy and performance of AI models trained with human faces, avatars, or landmarks
- -Spreadsheet containing emotion recognition datasets
- Final iteration of the emotion recognition AI tool

Deliverables Requiring Access to Campus

- Design Poster and Capstone EXPO poster: These will require campus access for printing. All team members regularly access campus and are physically able to print.

Remote Work Capabilities

- All coding, AI training, and other non-printing tasks can be performed remotely.

Resources Needed for Effective Remote Work:

- Access to the High-Performance Research Computing clusters at VCU
- GitHub repository for sharing code and other collaborative work

C.2 Milestones

Milestone	Description	Estimated Duration	Completion Date
1. Research Benchmarks and Existing Approaches	Conduct research on benchmarks and existing emotion recognition-based machine learning approaches.	10 days	Sept. 20

2. Choice of Architecture	Select the architecture to base the project on.	10 days	Sept. 30
3. Training of Models	Train models based on the chosen architecture.	4 weeks	Oct. 16
4. Report on Benchmark Tool Performance	Document the use of benchmark tools to test the performance of the model.	3 weeks	Nov. 7
5. First Framework of Emotion Recognition Tool	Develop the initial framework for the emotion recognition tool.	6 weeks	Nov. 25
6. Feedback Implementation for Second Draft	Implement feedback into the second draft of the emotion recognition tool framework.	3 weeks	Dec. 12
7. Development of Backend	Develop the backend for the emotion recognition AI tool prototype.	6 weeks	Jan. 30
8. Model Implementation into Prototype Software	Integrate the trained model into the prototype software.	4 weeks	Feb. 20
9. Development of Frontend	Create the frontend for the emotion recognition AI tool prototype.	3 weeks	March 12
10. Changes Based on Sponsor Feedback	Implement changes to the emotion recognition AI tool based on feedback from the sponsor.	3 weeks	April 1
11. Preparation for Expo Presentation	Prepare for the presentation of the emotion recognition AI tool at the expo.	3 weeks	April 22

C.3 Resources

Hardware

- The VCU High Performance Research Computing Core: For the training of the models used for emotion recognition. Access to already given by faculty sponsor.
- Meta Quest Pro headset: For assessing potential of VR and avatar in creating an emotion recognition tool.

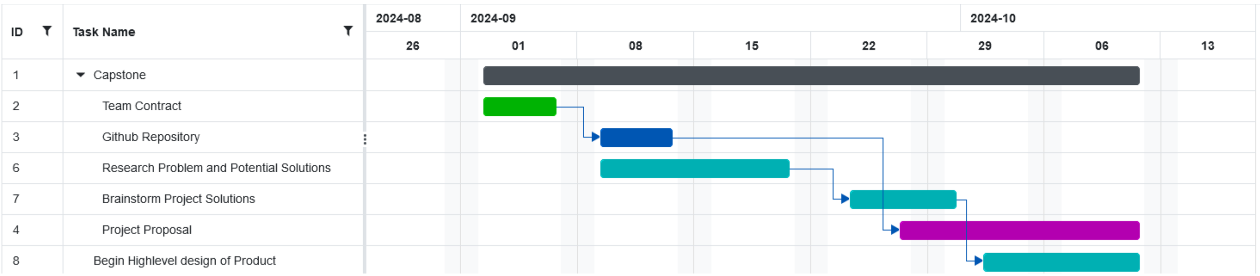
Databases

- 17 datasets outlined in Osman (2024): In use to train the model for increased out-of-domain robustness. Access given by faculty sponsor

Libraries

- The Pytorch Library: Library needed for deep learning capabilities. Publicly available

Appendix 1: Project Timeline



Appendix 2: Team Contract (i.e. Team Organization)

Step 1: Get to Know One Another. Gather Basic Information.

Team Member Name	***Strengths each member bring to the group***	***Other Info***	***Contact Info***
Aryan Rathi	I enjoy being punctual when it comes to assignments and deadlines. The sooner the better. I enjoy doing the most when it comes to my part of the assignment, expecting my teammates to do the same.	N/A talked with my group about my skillset!	*rathia@vcu.edu*
Philip Leake	I enjoy problem solving and excel at staying on top of work.	Talked with group	leakepa@vcu.edu
Youssef Bahloul	Encouraging discussion. Being proactive. Organizing and prioritizing tasks. Python.		bahlouly@vcu.edu
Theus Frase	Some natural language processing and machine learning experience		frasecm@vcu.edu

Other Stakeholders	***Notes***	***Contact Info***
Kostadin Damevski	Meeting 12-1 every Wednesday. Both sponsor and Faculty Advisor	kdamevski@vcu.edu

Step 2: Team Culture. Clarify the Group's Purpose and Culture Goals.

Culture Goals	***Actions***	***Warning Signs***
Collaboration	Team members actively engage in open communication, share diverse perspectives, and leverage each other's strengths to achieve common goals. For example, during brainstorming sessions.	Communication becomes stunted and members work independently without seeking input or collaboration from others, leading to missed opportunities and misunderstandings.
Accountability	Team members take ownership of their responsibilities, meet deadlines, and support one another in achieving their goals. For example, when our team faces challenges, team members work together in order to solve the issues and ensure success.	Accountability is not there, leading to missed deadlines, finger-pointing, and a lack of progress on commitments, ultimately hindering our team's progress and success.
Innovation	The team fosters a culture of continuous improvement and involvement, where members encourage and welcome new ideas. For example, during problem-solving sessions.	Resistance to change or a fear of failure stifles creativity, and team members become hesitant to suggest or experiment with new ideas.

Step 3: Time Commitments, Meeting Structure, and Communication

Meeting Participants	***Frequency Dates and Times / Locations***	***Meeting Goals Responsible Party***
Students Only	As Needed, On Discord Voice Channel	Update group on day-to-day challenges and accomplishments
Students Only	Wednesday at 2 in the library	Actively work on the project and update the plan for the week.
Students + Faculty advisor	Every Wednesday at 12 pm - 1pm in the second floor ERB.	Update faculty advisor and get answers to our questions. (Take notes during meeting; record the advisor's suggestions)

Step 4: Determine Individual Roles and Responsibilities

Team Member	***Role(s)***	***Responsibilities***
Youssef Bahloul	Project Manager	- Delegate tasks - Develop schedule - Run meetings
Philip Leake		- Coordinates interactions - Lead in establishing contact

	Logistics Manager & Github Engineer	- Obtaining information for the team - Documents meeting minutes - Manages facility and resource usage.
Theus Frase	Financial Manager	- Researches technical purchases and acquisitions - Conducts pricing analysis and budget justifications - Carries out team purchase requests - Monitors team budget.
Aryan Rathi	Systems/Test Engineer	- Analyzes Client initial design specification - Develops and recommends system architecture - Oversees experimental design, procedures and data analysis - Acquires data acquisition equipment and software - Establishes test protocols and schedules - Oversees statistical analysis of results - Leads presentation of experimental finding and resulting recommendations.

Step 5: Agree to the above team contract

Team Member: Philip Leake *Signature: __Philip Leake____*

Team Member: Aryan Rathi *Signature: __Aryan Rathi____*

Team Member: Theus Frase *Signature: __Theus Frase____*

Team Member: Youssef Bahlou *Signature: __Youssef Bahloul_*

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