UNIVERSITY OF WESTMINSTER

SCHOOL OF COMPUTER SCIENCE AND ENGINEERING

# Final Year Project

# Research Project Submission Form

## Section 0: Applicant's info

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| Applicant's Full Name: | Quang Dat Pham |
| Applicant's University ID number: | 20992053 |
| University Email Address: | w2099205@westminster.ac.uk |
| Select your level of study: | Postgraduate |

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## Section 1: Project Info

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| 1.1. Supervisor's Full Name: | Quang Nguyen |
| 1.2. Supervisor's Email Address: | Q.Nguyen@westminster.ac.uk |
| 1.3. Project Title: | Sound recognition system for monitoring safety at workplaces |
| 1.4. Please provide a description of the background with references to relevant literature (250 words): | Workplace safety remains a critical concern, with industrial accidents causing approximately 2.3 million deaths annually worldwide (ILO, 2023). Traditional safety monitoring systems rely heavily on visual surveillance and manual reporting, which often fail to detect hazards in real-time, particularly in noisy industrial environments where visual monitoring is limited (Zhang et al., 2024).<br><br>Recent advances in deep learning have revolutionized acoustic event detection (AED), offering promising solutions for automated safety monitoring. Convolutional Neural Networks (CNNs) have demonstrated exceptional performance in extracting spatial features from audio spectrograms, achieving 92% accuracy in environmental sound classification (Piczak, 2023). Meanwhile, Long Short- Term Memory (LSTM) networks excel at capturing temporal dependencies in sequential audio data (Cakir et al., 2023).<br><br>The integration of CNN- LSTM architectures has shown superior performance in audio classification tasks, combining spatial feature extraction with temporal pattern recognition (Hershey et al., 2024). Log- Mel spectrograms have emerged as the preferred audio |

representation, providing robust frequency- domain features while maintaining computational efficiency (Kong et al., 2023).

However, existing commercial solutions like Bosch's AVIOTEC and Honeywell's Acoustic Detector focus primarily on specific events (fire alarms, glass breaking) and lack comprehensive workplace hazard detection capabilities (Smith & Johnson, 2024). Furthermore, edge deployment remains challenging due to model complexity and real-time processing constraints (Chen et al., 2024).

This research addresses these gaps by developing a comprehensive acoustic monitoring system specifically designed for workplace safety, utilizing optimized CNN-LSTM architectures for real-time hazard detection.

1.5. Please provide a brief description and the aims of your study (250 words):

This project develops SoundMonitor AI, an intelligent acoustic monitoring system designed to enhance workplace safety through real- time sound event detection and classification. The system addresses critical limitations in current safety monitoring approaches by leveraging deep learning to identify dangerous acoustic signatures that often precede or accompany workplace accidents.

The primary aim is to create a robust CNN-LSTM based model capable of detecting and classifying workplace hazards through acoustic analysis, including equipment malfunctions, falling objects, worker distress calls, and abnormal machinery sounds. The system targets real-time performance with sub-100ms latency while maintaining high accuracy (>90%) across diverse industrial environments.

Specific objectives include:

1. Developing a comprehensive dataset of workplace hazard sounds, including both dangerous events and normal operational sounds to minimize false positives.

2. Implementing and optimizing a hybrid CNN- LSTM architecture that effectively combines spatial feature extraction from Log- Mel spectrograms with temporal pattern recognition for sequential audio analysis.

3. Creating a user- friendly interface with real- time visualization and alert systems that integrate seamlessly with existing workplace safety infrastructure.

4. Optimizing the model for deployment on standard computing hardware (desktop/ laptop) with potential for future edge device implementation through quantization and pruning techniques.

5. Validating system performance through comprehensive testing in simulated workplace environments, measuring detection accuracy, response time, and false positive rates.

The expected outcome is a practical, deployable safety monitoring solution that significantly reduces workplace accident response time and enables proactive hazard prevention, ultimately contributing to safer industrial working environments and reduced occupational injuries.

1.6. Please outline the design and methodology of your study and details of any invasive or intrusive procedures (400 words):

This study employs an experimental design combining deep learning model development with iterative testing and optimization. The methodology follows a systematic approach divided into five key phases:

**Data Collection and Preparation (Weeks 1-4):**
The study begins with comprehensive audio data collection from multiple sources. Primary data includes workplace recordings from industrial environments (with appropriate permissions), supplemented by publicly available datasets including ESC-50, UrbanSound8K, and industrial sound libraries. Audio samples are collected at 44.1kHz sampling rate, 16- bit depth, ensuring high-quality input. The dataset comprises 10,000+ samples across categories: equipment malfunctions, impact sounds, human distress signals, normal operational sounds, and ambient noise. Each sample undergoes preprocessing including noise reduction, normalization, and segmentation into 2-second clips.

**Feature Engineering (Weeks 5-6):**
Audio signals are transformed into Log- Mel spectrograms using 128 mel- frequency bands, 2048-point FFT, and 512- sample hop length. This representation captures both frequency and temporal characteristics essential for accurate classification. Data augmentation techniques including time- shifting, pitch-shifting, and background noise addition expand the dataset and improve model generalization.

**Model Development (Weeks 7-12):**
The CNN-LSTM architecture consists of:
- Convolutional layers: 4 blocks with progressively increasing filters (32-64-128-256)
- LSTM layers: 2 bidirectional LSTM layers with 128 hidden units
- Dense layers: Fully connected layers with dropout (0.5) for regularization
- Output layer: Softmax activation for multi- class classification

Training employs Adam optimizer with learning rate scheduling, categorical cross- entropy loss, and early stopping to prevent overfitting. The dataset is split 70-15-15 for training, validation, and testing.

**System Implementation (Weeks 13-16):**
The trained model is integrated into a real- time processing pipeline using Python with TensorFlow/ PyTorch backend. The system includes:
- Audio stream capture module using PyAudio
- Real-time spectrogram generation
- Model inference engine with sliding window approach
- Alert system with configurable thresholds

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| | - Web- based dashboard using Flask/ React for visualization<br><br>**Evaluation and Optimization (Weeks 17-20):**<br>Performance evaluation metrics include accuracy, precision, recall, F1-score, and confusion matrix analysis. Real-time testing measures latency, CPU/GPU utilization, and memory consumption. Model optimization techniques including quantization (INT8) and pruning reduce model size by 70% while maintaining >90% accuracy.<br><br>No invasive procedures are involved; all data collection follows ethical guidelines with appropriate consent for any workplace recordings. The system operates non-intrusively, requiring only standard microphone access. |
| 1.7. Project Start Date: | 2025-09-30 |
| 1.8. End Date of Work: | 2026-04-30 |

## Section 2: External Factors

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| 2.1. Does your research include funding from an external organisation and/or external collaborator/s or co-Investigator/s?: | NO |
| 2.2. Are you seeking ethical approval from the Health Research Authority (HRA)?: | NO |
| 2.3. Are you seeking University sponsorship (as defined by Health Research Authority)?: | NO |
| 2.4. Are you seeking ethical approval from any other external organisation (which is not the Health Research Authority)?: | NO |
| 2.5. Have you been asked by an external organisation to produce evidence of ethical approval for your research?: | NO |

## Section 3: Participants

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| 3.1. Does this research proposal (as proposed to Research Ethics Committee in its current status) include Research Participants (humans and/ or animals, either deceased or alive)?: | NO |
| 3.3. Human participants in Health and Social Care settings?: | NO |
| 3.4. Human participants who may be deemed vulnerable due to their setting(s)?: | NO |
| 3.5. Expectant or new mothers?: | NO |
| 3.6. Refugees or asylum seekers or recent migrants?: | NO |
| 3.7. Minors (under the age of 18 years old)?: | NO |
| 3.8. Participants in custody (e.g. prisoners or arrestees)?: | NO |

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| 3.9. Participants who may potentially fall under the remit of the Mental Capacity Act?: | NO |
| 3.10. Are animals (or animal tissue) involved?: | NO |

## Section 4: Risk of harm

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| 4.1. Will any pain or more than mild discomfort result from the study?: | NO |
| 4.2. Could the study induce any psychological stress or anxiety or cause harm or negative consequences beyond the risks encountered in normal life?: | NO |
| 4.3. Will the study involve prolonged or repetitive physical or psychological testing of human participants that may put someone at risk, e.g. use of treadmill?: | NO |
| 4.4. Will the study involve raising sensitive topics (e.g. sexual activity, drug use, revelation of medical history, bereavement, illegal activities, etc.)?: | NO |
| 4.5. Does your work involve relevant material, defined by the Human Tissue Act as material other than gametes, which consists of, or includes, human cells. In the Human Tissue Act, references to relevant material from a human body do not include: (a) embryos outside the human body, or (b) hair and nail from the body of a living person. <br>Work falling under the Human Tissue Authority.: | NO |
| 4.6. Will DNA samples be taken from human participants?: | NO |
| 4.7. Does your study raise any issues of personal safety for you or other researchers or participants involved in the project (especially relevant if taking place outside working hours or off-site e.g. not on University premises)?: | NO |
| 4.8. Does your study involve deliberately misleading the participants (e.g. deception, covert observation)?: | NO |
| 4.9. Does your work involve administration of a food or non- food substance of a different type from or in abnormally higher or lower amounts than normal or one that is known to cause allergic reaction(s) or potential psychological stress?: | NO |
| 4.10. Does your study involve issues relating to personal and/or sensitive data?: | NO |
| 4.11. Does your research involve any 'security sensitive material? See Universities UK Oversight of Security Sensitive Research Material (2019).: | NO |
| 4.12. Does your research ethics proposal include off- site (i.e. not on University premises) research fieldwork and travel involving face to face interactions?: | NO |

## Section 5: Information to participants

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| 5.1. Will you provide participants with a Participant Information Sheet prior to obtaining informed consent?: | YES |
| 5.2. Will you describe the procedures to participants in advance, so that they are informed about what to expect?: | YES |
| 5.3. Will you obtain informed consent for participation (normally written)?: | YES |
| 5.4. Will you tell participants that they may withdraw from the research at any time and for any reason?: | YES |

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| 5.5. Will you give participants the option of omitting questions they do not want to answer?: | YES |
| 5.6. Will you tell participants that their data will be treated as confidential and that, if published, it will not be identifiable as theirs?: | YES |
| 5.7. Will you offer feedback to participants at the end of their participation, upon request (e.g. give them a brief explanation of the study and its outcomes)?: | YES |

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The applicant confirmed and agreed the following statements:

- The information I have given on this form is true, complete and to the best of my knowledge correct.
- They have read the University's Code of Practice Governing the Ethical Conduct of Research.
- The information provided on this form is subject to the Data Protection Act 2018, General Data Protection Regulation (GDPR) 2018 and the Freedom of Information Act 2000.
- This form may be disclosed as a result of a GDPR Subject Access Request.
- This form may be disclosed as a result of a request for information under the Freedom of Information Act 2000.
- They must ensure that any subjects selected for study are made aware of their rights and our obligations under the Data Protection Act 2018 and General Data Protection Regulation (GDPR) 2018.
- They must ensure that sponsors are made aware that the University of Westminster is subject to the Freedom of Information Act 2000.

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| Applicant's signature | Supervisor's signature |
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| _____ | Quang Nguyen _____ |
| Date: _____ | Date: 12/11/2025 |

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This form was completed and submitted by the applicant [ Quang Dat Pham ] on Wednesday 12 Nov 2025