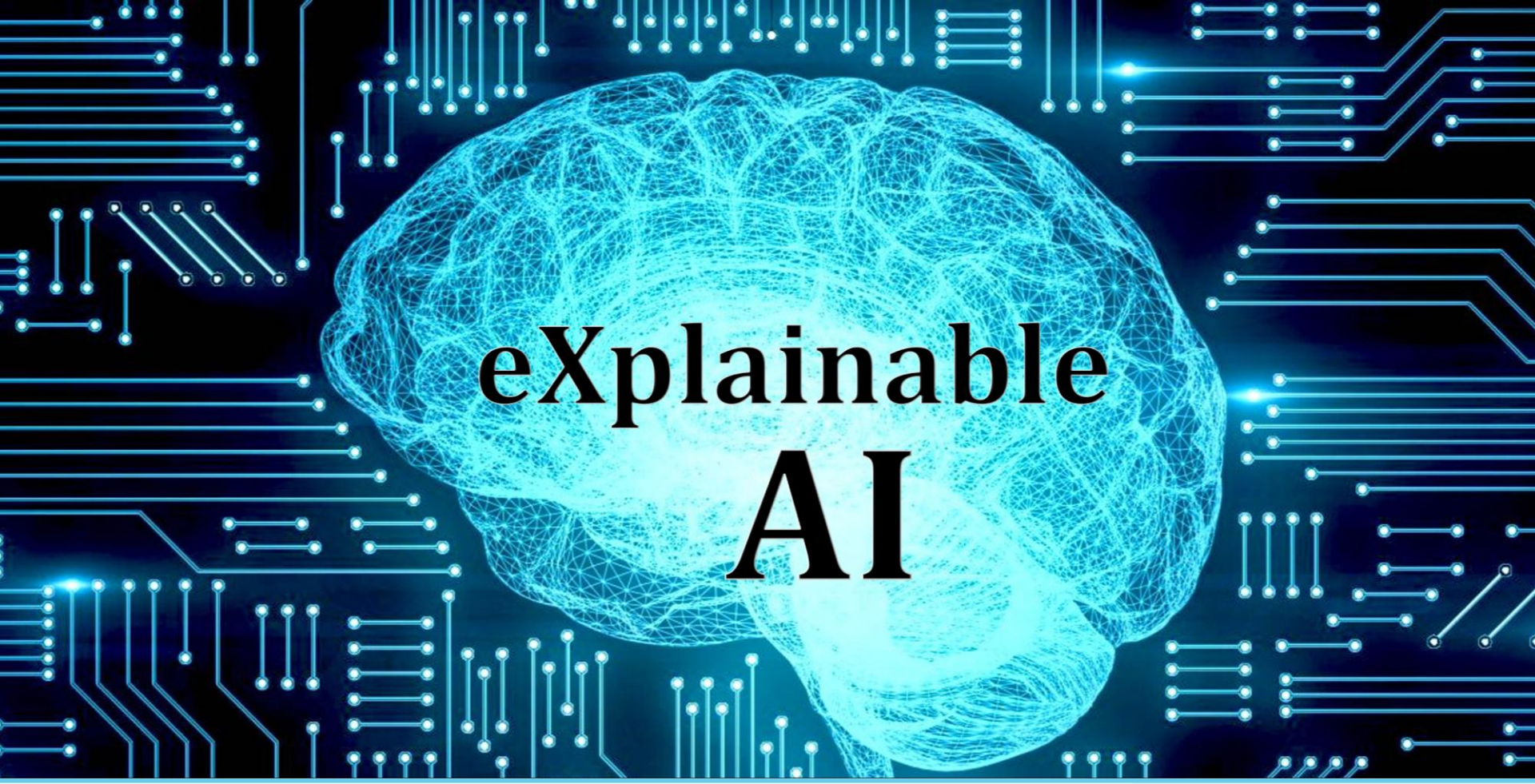


University of Sheffield /AMRC North West

Digital Team

AI Readiness For Inspection (AIRI)

Mohammad Nadeem Ahangar

12th September 2025

European Union
European Regional Development Fund

Lancashire Enterprise Partnership

NORTHERN POWERHOUSE

CATAPULT High Value Manufacturing

UKRI Innovate UK

TOMORROW. DONE BETTER.

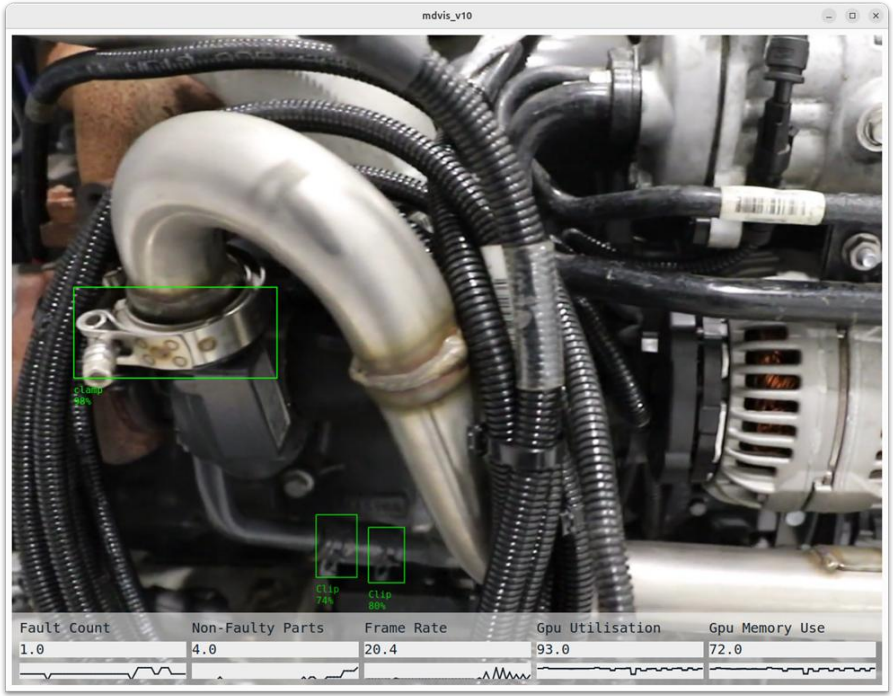
Artificial Intelligence (AI) – Definition

"Artificial Intelligence refers to the capability of a computer system to perform tasks that normally require human intelligence, such as learning, reasoning, problem-solving, perception, and decision-making."

Source: *IBM, What is Artificial Intelligence?*

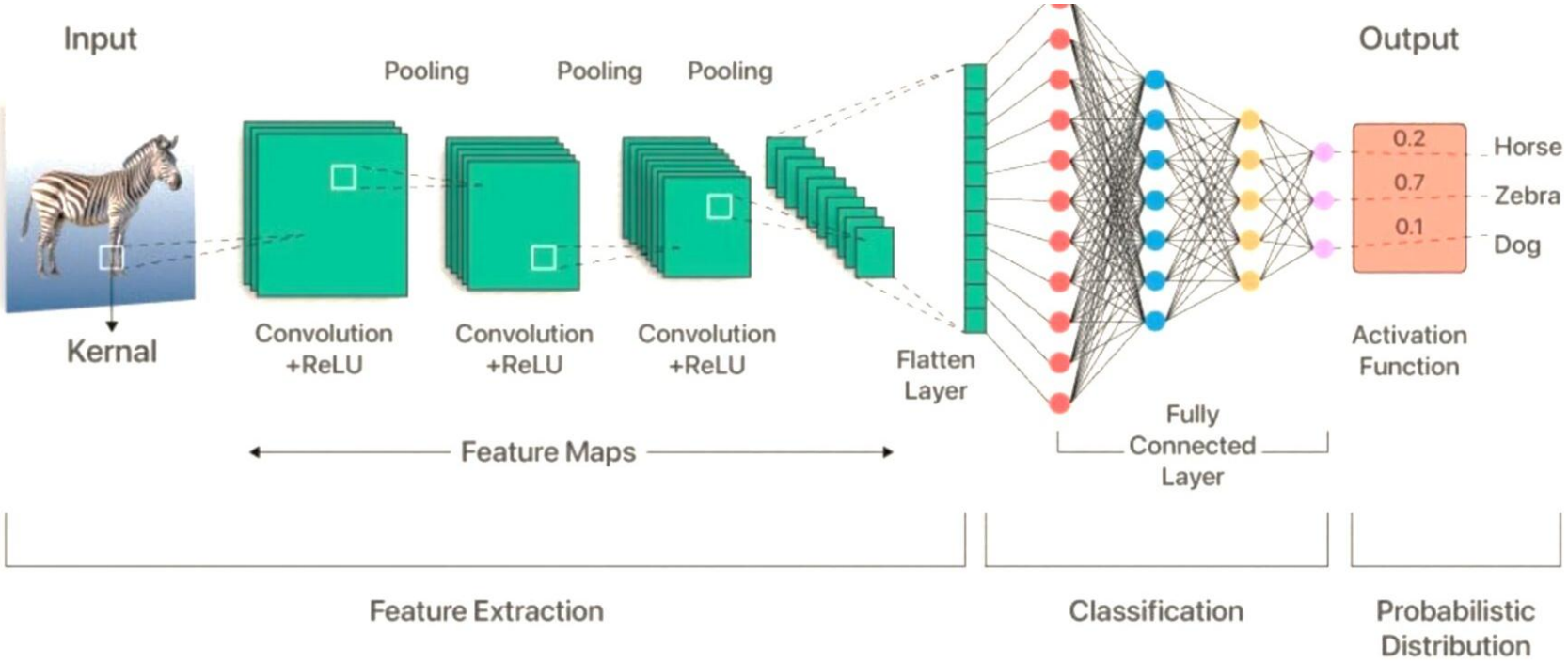
AI Use Cases in Industry 5.0

- Quality Control → Automated defect detection
- Predictive Maintenance → Anticipate failures, save costs
- Energy Management → Efficiency + sustainability
- Inventory Management → Smarter stock levels, reduced waste
- Generative Design → Faster, optimised product designs
- Digital Twin → Virtual simulations for optimisation
- Custom Manufacturing → Personalised production at scale
- Supply Chain Management → Demand forecasting, resilient logistics



Quality Inspection Using AI (Leyland Truck Project)

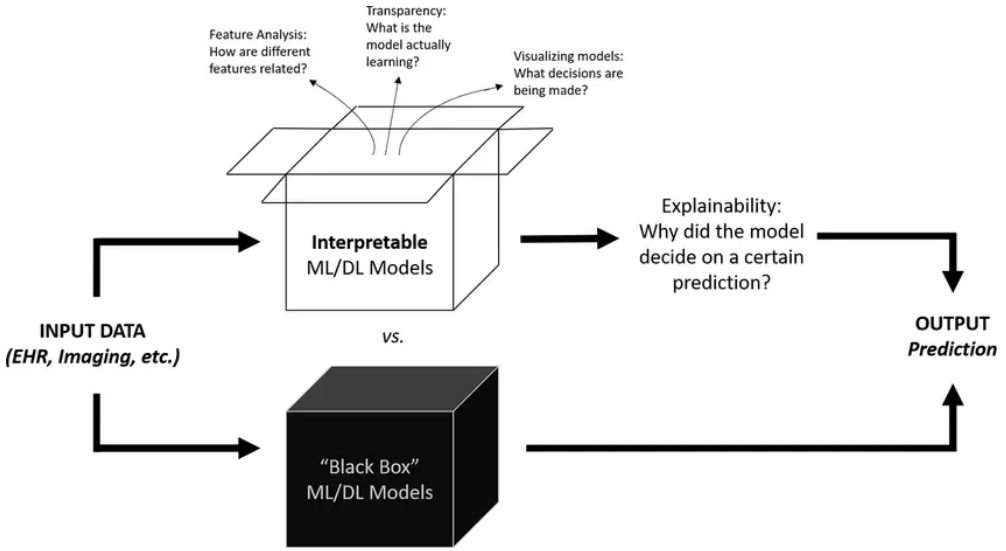
AI Pipeline



[General AI Pipeline]

Why Normal AI Feels Like a Black Box

- Deep models often lack transparency in their internal reasoning.
- Even domain experts find it difficult to interpret how these models work.
- High-stakes applications (e.g., safety inspections) require clear reasoning, not just outputs.
- Explainable AI (XAI) helps by showing how and why decisions are made, keeping humans in the loop.



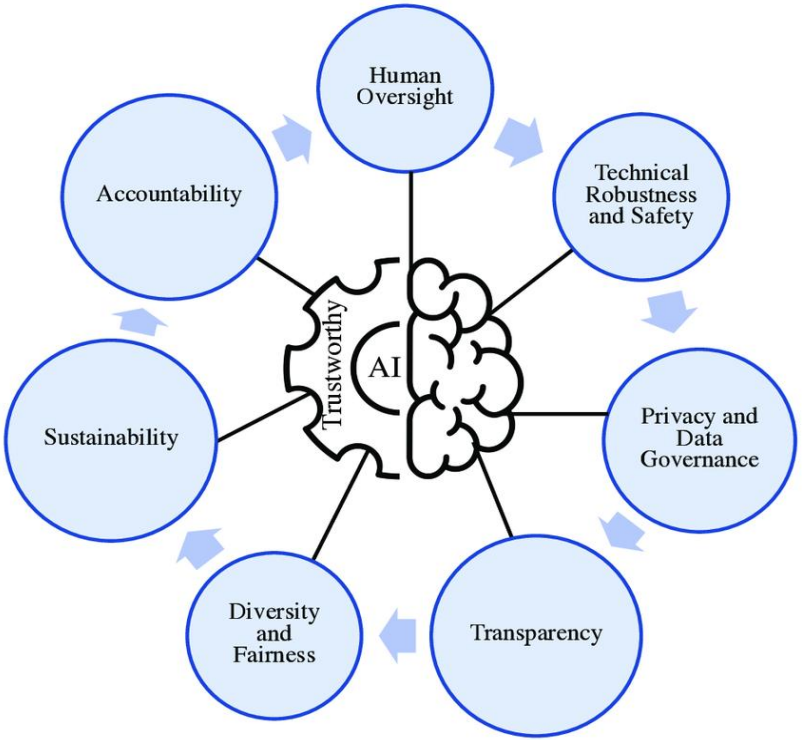
[Blackbox Issue and Explainable AI]

Real-World Examples of Hidden AI Risks:

Case	When / Where	Who (Developer / Target)	Key Issue
COMPAS (Correctional Offender Management Profiling for Alternative Sanctions)	2016 / USA	Northpointe (Equivant) used in courts	Racial bias in recidivism risk
Amazon Recruitment Tool	2014–2018 / Seattle	Amazon's ML team	Gender bias against women
Self-Driving Car Failure	March 2018 / Arizona	Uber ATG; pedestrian Elaine Herzberg	Fatal crash; AI failed to explain
Medical Diagnosis AI	2019+ / Global	Google Health, IBM Watson etc.	Opaque, unexplainable decisions

Why Explainability Matters: Real-World AI Incidents

AI Trustworthiness



"AI trustworthiness refers to the confidence and reliability stakeholders have in artificial intelligence systems, encompassing factors such as reliability, transparency, fairness, privacy, security, accountability, and ethical use" [1] [2]

Key Organisations Setting AI Standards

Organisation	Framework / Focus	Relevance
European Commission (EU)	*Ethics Guidelines for Trustworthy AI*	Human-centric, lawful, ethical, robust AI
NIST (US) (National Institute of Standards and Technology)	*AI Risk Management Framework (AI RMF 1.0)*	Risk, trust, reliability, transparency
OECD (Organisation for Economic Co-operation and Development)	*Principles on Artificial Intelligence*	Global principles on fairness, transparency, accountability
ISO / IEC	*International AI Standards*	Technical robustness, interoperability, safety
IEEE	*Ethically Aligned Design*	Embedding ethics in AI system design
Singapore	*Model AI Governance Framework*	Practical guidelines for responsible AI deployment

Organisations Setting AI Standards

Key Explainable AI (XAI) Techniques

Technique	How it Works	Best For
Grad-CAM (Gradient-weighted Class Activation Mapping)	*Highlights regions in an image most responsible for a prediction*	Computer vision tasks (e.g., defect detection in inspection)
Occlusion Sensitivity	*Hides parts of the input and observes how prediction changes*	Understanding which image areas influence decisions
Saliency Maps	*Uses gradients to show which pixels most affect the model's output*	Visualising fine-grained features in image classification
Integrated Gradients	*Attributes importance of each input feature by comparing baseline vs. actual input*	Image and tabular data where feature attribution is needed
Feature Importance (SHAP/LIME style)	*Ranks input features by how much they affect predictions*	Tabular data, predictive maintenance, quality decisions

XAI Techniques

AIRI Project

AIM: Explore how trustworthy AI can be integrated into aerospace manufacturing inspections (NDT), with a focus on Explainable AI (XAI) to build confidence and support human inspectors.

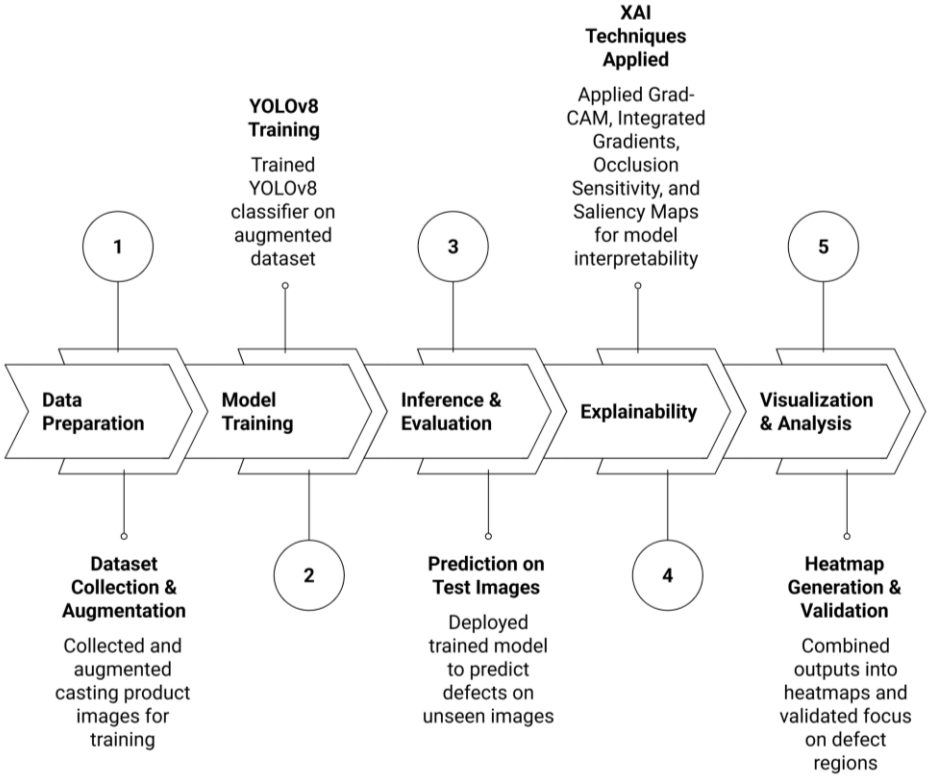
Objectives:

- Assess AI's role in improving efficiency, reliability, and compliance in aerospace manufacturing.
- Identify areas where AI can safely complement human inspectors.
- Gather insights from industry practitioners (e.g., BAE Systems) on challenges and opportunities for AI in NDT.
- Develop a demonstrator showing how XAI can support inspection decisions in practice.

Real-Life Industrial Dataset of Casting Product Source: Link 1

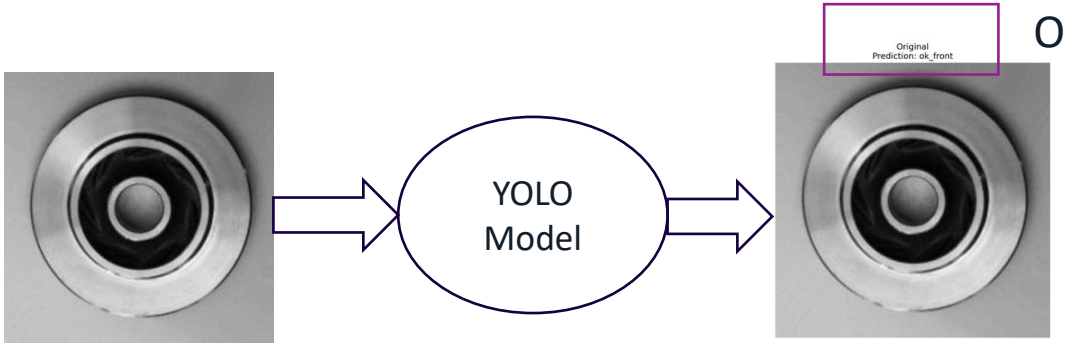
- **Domain:** Industrial quality inspection for casting manufacturing.
- **Content Description:**
  - Contains top-view images of submersible pump impellers used in casting processes.
  - Images are categorized into two classes: “Defective” and “Ok” (i.e., non-defective).
  - Includes a total of approximately 7,348 grayscale images.
- **Data Structure:**
  - Images vary in resolution, including both 300×300 and 512×512 pixel sizes.
  - Dataset is split into training and test sets:
    - Training: ~3,758 “Defective” images and ~2,875 “Ok” images.
    - Testing: ~453 “Defective” and ~262 “Ok” images.
- **Applications & Value:**
  - Primarily used for defect classification tasks in automated visual inspection workflows within casting manufacturing.
  - Serves as a benchmark for developing and evaluating deep learning models (e.g., CNNs, Xception) aimed at improving quality control and reducing human inspection errors.

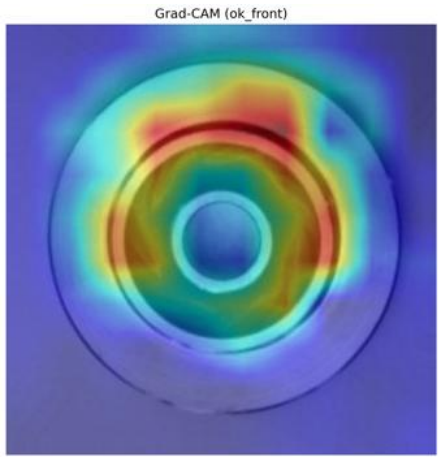
Real-Life Industrial Dataset of Casting Product Source: [Link 1]

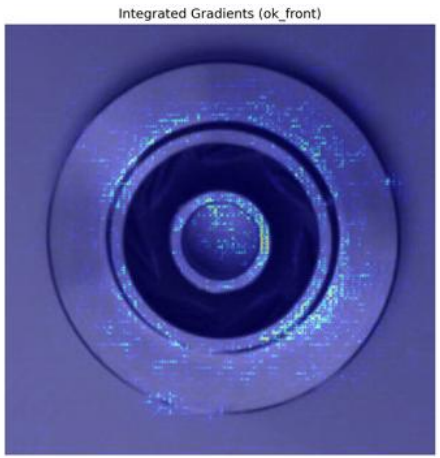


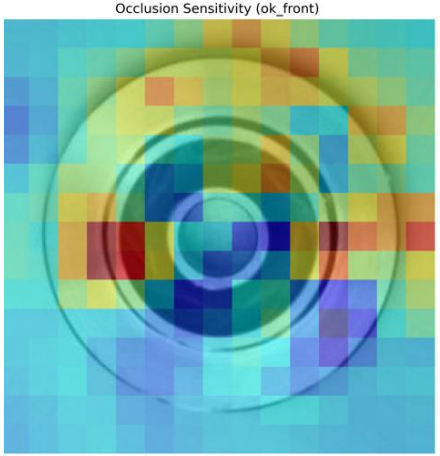
Methodology

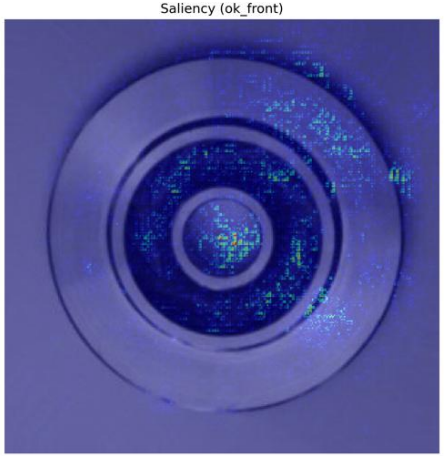
Results



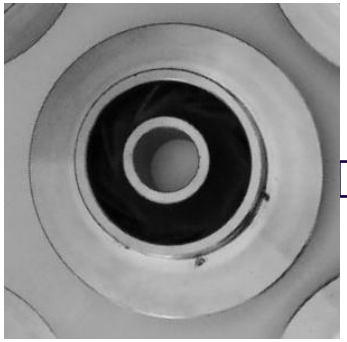




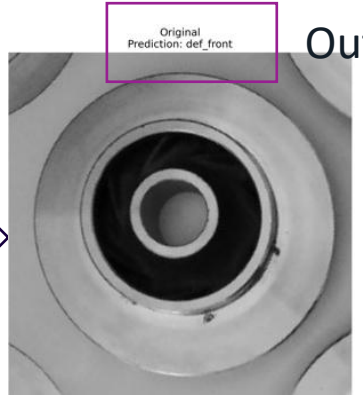




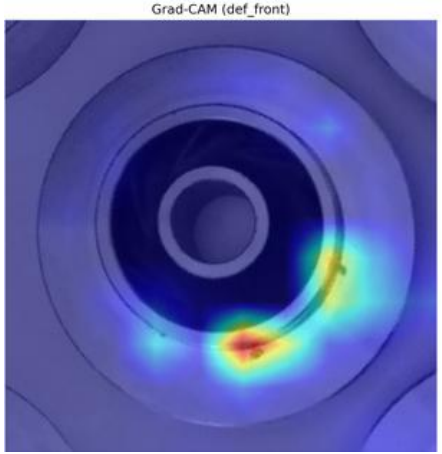
Results

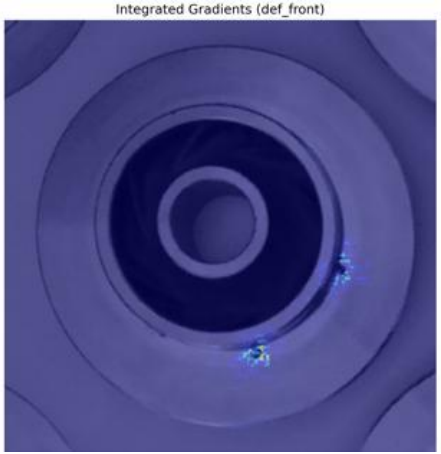


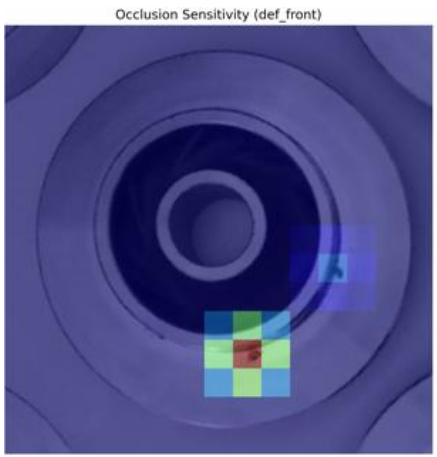
YOLO Model

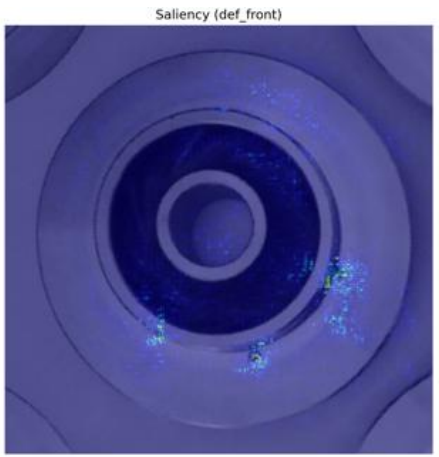


Output



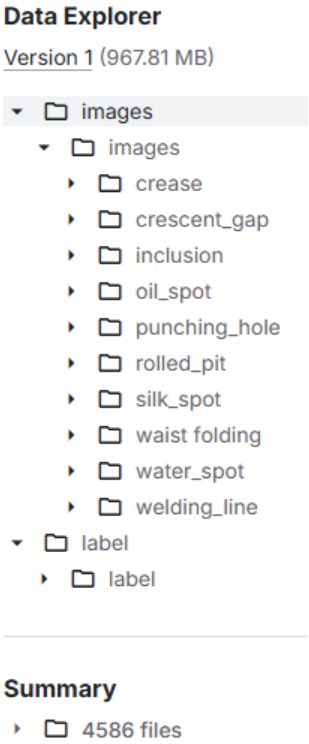




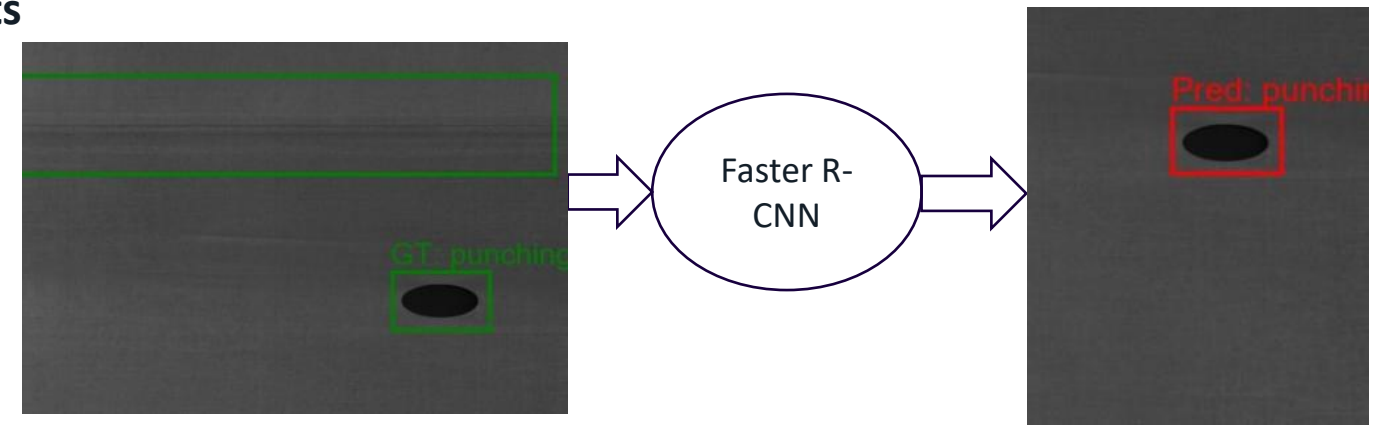


Defect Location for Metal Surface Source Link 2

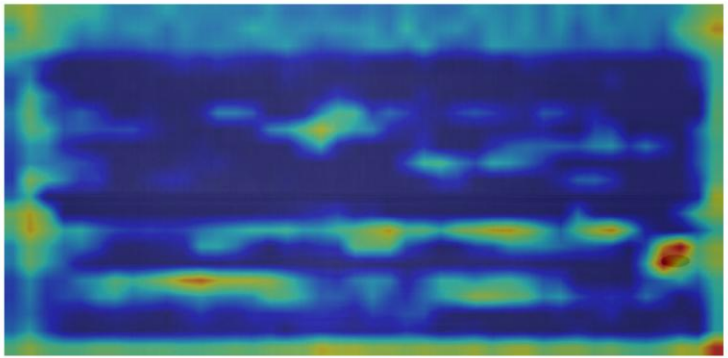
- **Domain**: Industrial inspection, with a focus on metal surface defect analysis.
- **Content**: Image dataset annotated with both defect classes (types of defects) and defect locations (bounding box or coordinate-based annotations).
- **Purpose**: Enables research and development of AI models for defect classification and defect localization.
- **Applications**: Supports explainable and automated visual inspection in manufacturing, particularly for quality assurance and predictive maintenance.
- **Value**: Provides a benchmark resource for evaluating computer vision methods in industrial defect detection tasks.



Results

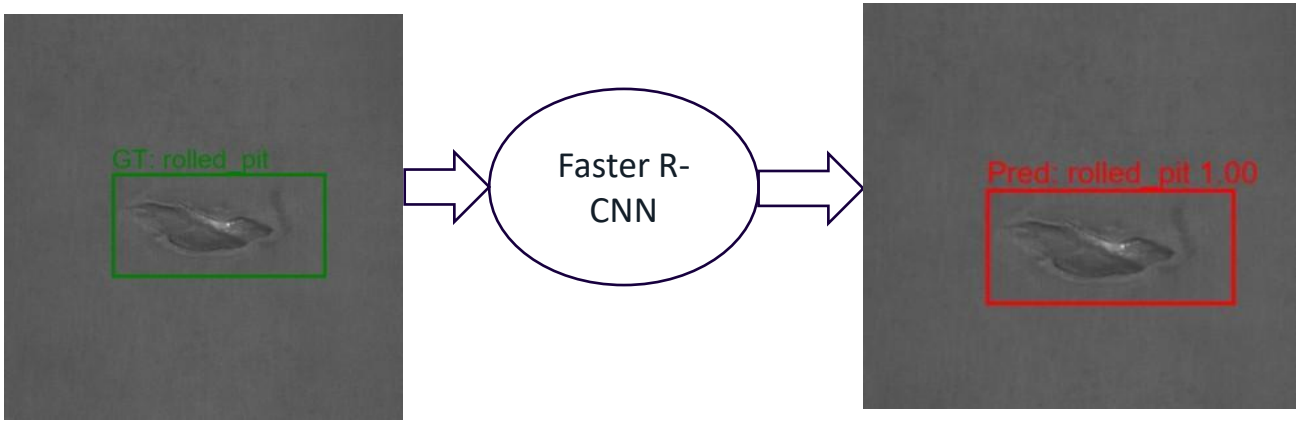


Grad-CAM Heatmap

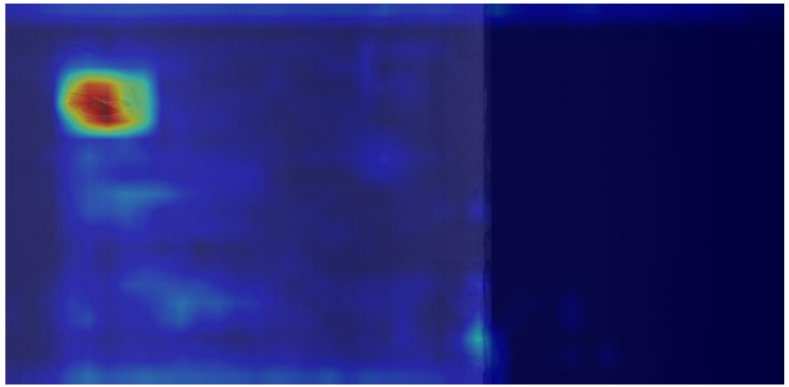


Saliency Map

Results



Grad-CAM Heatmap

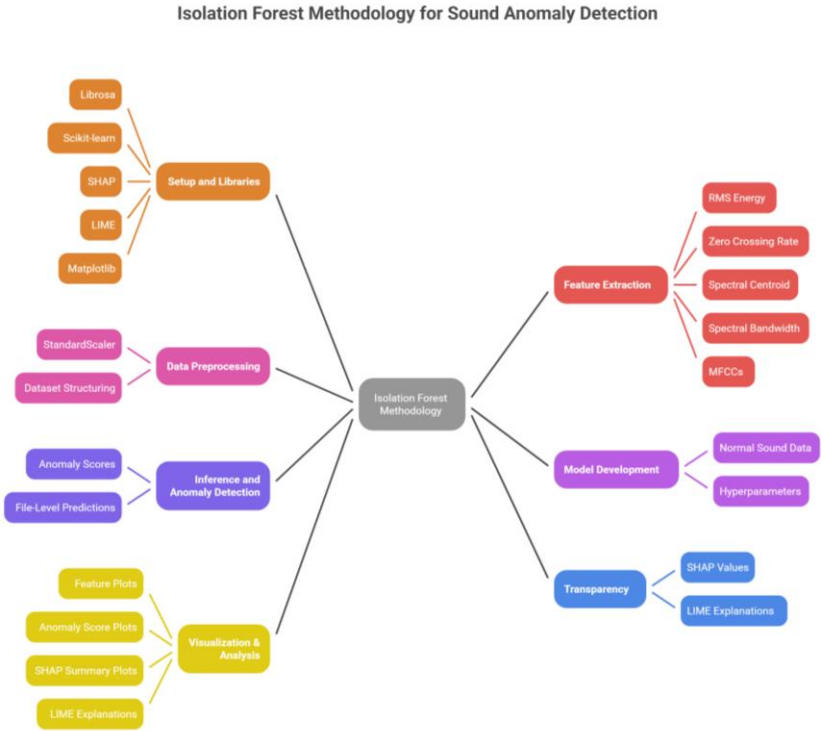


Saliency Map

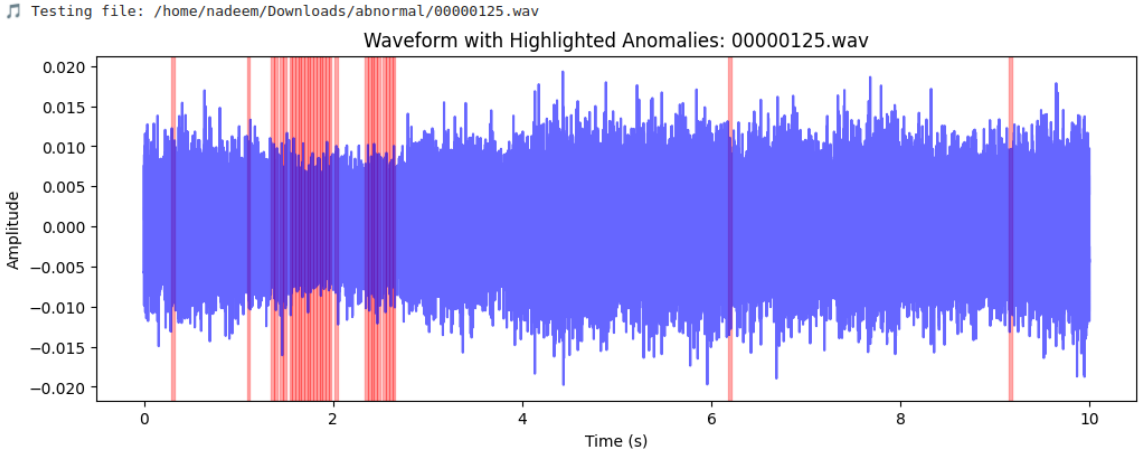
MIMII Dataset (Malfunctioning Industrial Machine Investigation & Inspection) Source: Hitachi Research Team – Zenodo

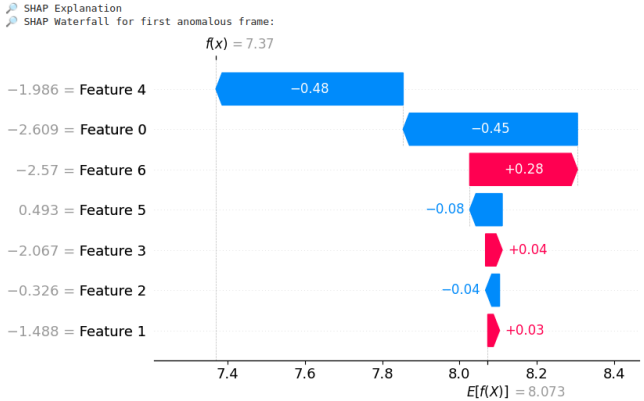
- **Domain**: Industrial anomaly detection via sound.
- **Machines**: Valves, Pumps, Fans, Slide Rails (7 models each).
- **Data**: ~26k normal sounds, ~6k anomalous sounds.
- **Specs**: 16 kHz, 16-bit, 8-channel mic array; factory noise included.
- **Anomalies**: Contamination, leakage, unbalance, rail damage, etc.
- **Use Cases**: Benchmark for unsupervised anomaly detection, transfer learning, noise robustness.
- **Baseline**: Autoencoder model provided.
- **License**: CC BY-SA 4.0 (open access)

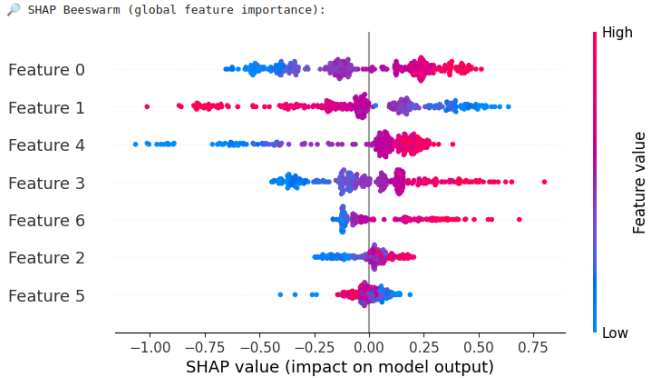
MIMII Dataset (Malfunctioning Industrial Machine Investigation & Inspection) Source: Hitachi Research Team – [Zenodo]



Results

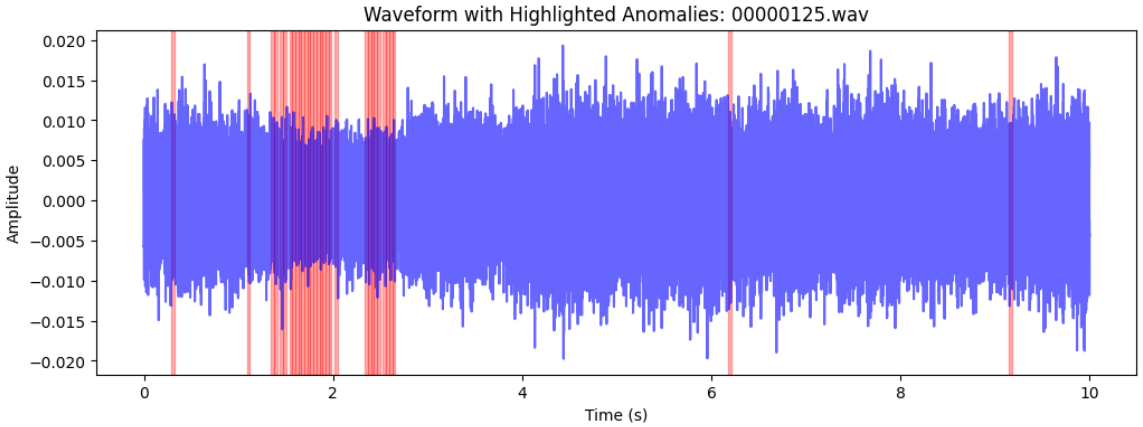




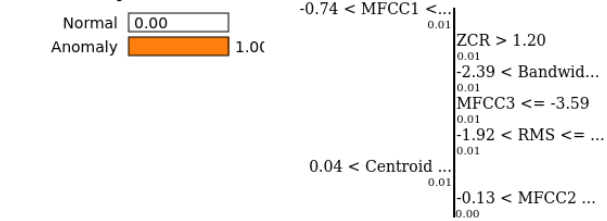


Results

🎵 Testing file: /home/nadeem/Downloads/abnormal/00000125.wav

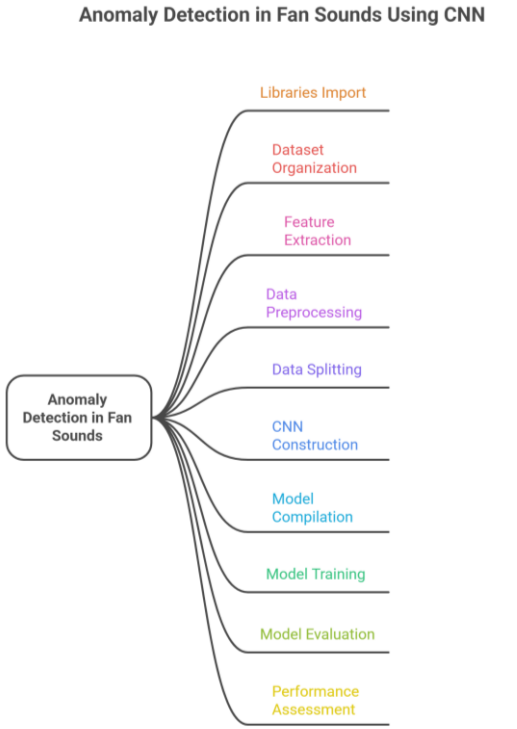


🔎 LIME Explanation
Intercept 0.9876182616456224
Prediction_local [1.0069769]
Right: 1
🔎 LIME explanation for frame 251

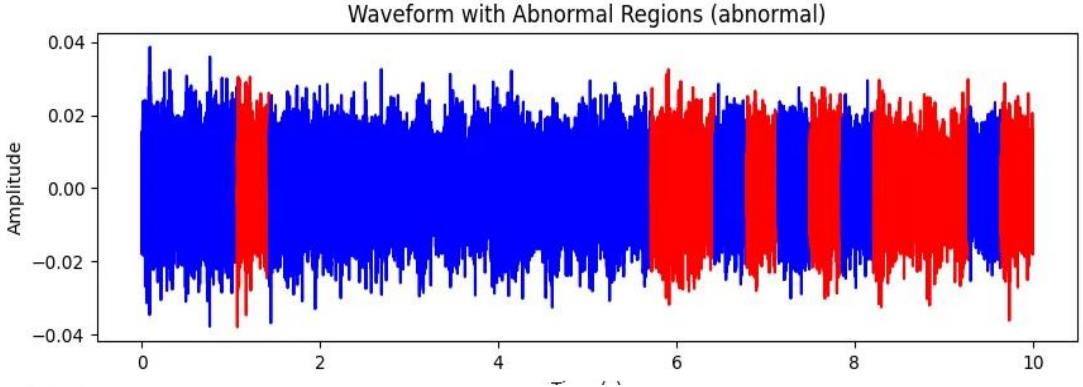


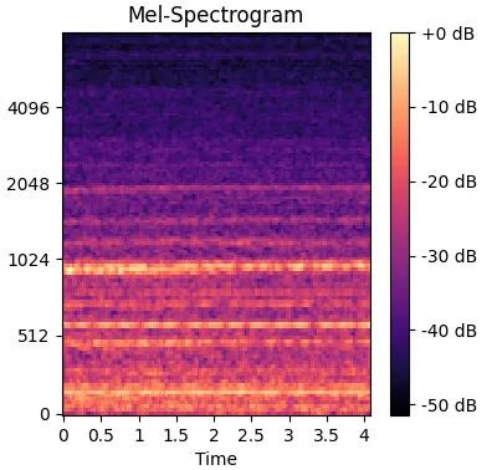
Feature	Value
MFCC1	-0.62
ZCR	1.26
Bandwidth	-2.18
MFCC3	-3.64
RMS	-1.68
Centroid	0.08
MFCC2	-0.08

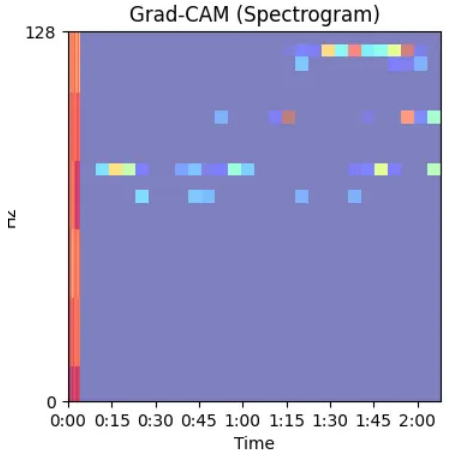
MIMII Dataset (Malfunctioning Industrial Machine Investigation & Inspection) Source: Hitachi Research Team – [Zenodo]



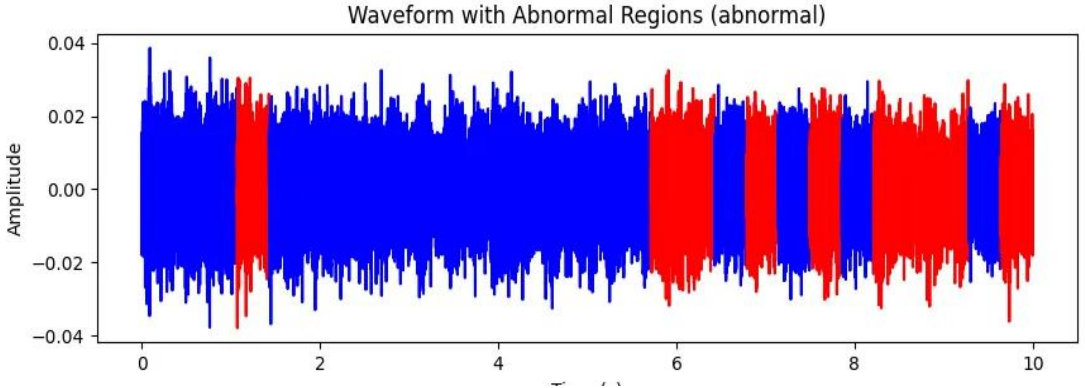
Results







Results



Prediction

abnormal

abnormal 100%

normal 0%

Explanation

Prediction: abnormal (99.84% confidence). Abnormality strongest at: 1.11-1.48s, 5.93-6.67s, 7.04-7.41s, 7.78-8.15s, 8.52-9.63s, 10.0-10.0s.

Conclusion

- Demonstrated how **Explainable AI (XAI)** can enhance trust, transparency, and reliability in industrial inspection tasks.
- Showed practical value through real-world datasets and models (YOLO, Faster R-CNN, MIMII) for defect detection and anomaly analysis.
- **Positioned AI as a decision-support tool**:
  - Assists human inspectors by **highlighting potential defects/anomalies** quickly and accurately.
  - Reduces repetitive workload, allowing inspectors to focus on **complex, safety-critical judgments**.
  - Improves consistency across inspections by providing **objective, data-driven insights.**
  - Ensures **human-in-the-loop oversight**, keeping accountability with inspectors while enhancing confidence in AI outputs.

Questions?

Thank you.

For further information please contact or visit:

m.n.ahangar@hud.ac.uk

+447399368792

amrc.co.uk

@TheAMRC | @TheAMRC | @TheAMRC | @AMRC | @the_amrc

TOMORROW. DONE BETTER.