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(Autonomous)
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MSME IDEA HACKATHON 5.0

Idea theme: Smart Automation

Title of proposed idea: "AI-Powered Automated System for Monitoring Faulty Exhibits in Science Museums "

Introduction

To create interactive learning experiences, interactive science museums employ displays with movable parts, screens, and sensors. Technical problems in such displays often go unnoticed due to the lack of staff and the impracticality of continuous manual monitoring. As a result, visitors become annoyed, learning scores decline, and museums' reputations suffer. This project aims to develop an AI-based system that automatically detects faulty displays in real-time, enabling immediate maintenance and ensuring a seamless visitor experience. The solution seeks to revolutionize exhibit management and transform museums into futuristic, visitor-centered organizations by integrating cameras, sensors, and smart analytics.

Literature Survey

1. A Deep Learning-Based Framework for Anomaly-Based Damage Detection in Cultural Heritage Structures (2023)

Authors: Abbas, M., Zhao, Z., & Yan, R.

This paper introduces a deep learning framework that utilizes Convolutional Neural Networks (CNNs) for the real-time detection of anomalies and potential damage to cultural heritage buildings. By analyzing video streams, the system can identify cracks, spalling, and other structural defects. The research demonstrates high accuracy in controlled environments, proving the viability of automated visual inspection for preservation. However, its focus remains on the static and structural integrity of facades, lacking the capability to monitor the functional or interactive aspects of an exhibit. It does not address non-visual defects, such as software glitches or mechanical failures, which are common in science museum displays.

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2. Multi-Sensor Fusion for Real-Time Anomaly Detection in Interactive Public Kiosks (2022)

Authors: Li, Q., & Chen, W.

This work details a system that fuses data from multiple sensors—including cameras, microphones, and touch sensors—to detect anomalous user interactions and hardware malfunctions in public information kiosks. The system employs a Recurrent Neural Network (RNN) to analyze time-series data and identify patterns indicative of vandalism, software freezes, or component failure. While highly relevant for its multi-modal approach, the system is tailored to relatively simple interactive devices with predictable user inputs. It is not designed to handle the complex and diverse range of interactions found in science museum exhibits, which often involve unique physical and digital elements.

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3. YOLO-Based Real-Time Object Detection for Monitoring Visitor Interaction in Museum Environments (2024)

Authors: Hernandez, G., & Kim, J.

In this study, the authors apply the YOLO (You Only Look Once) algorithm to monitor how visitors interact with museum artifacts behind glass. The system can detect when a visitor gets too close, touches the glass, or uses flash photography, sending real-time alerts to staff. The research highlights the potential of YOLO for real-time behavioral analysis in public spaces. The primary limitation is its focus on visitor behavior rather than the operational status of the exhibits themselves. It is designed to protect static displays, not to diagnose malfunctions in interactive, mechatronic systems.

**4. An Intelligent Fault Diagnosis System for Robotic Arms Based on Deep

Learning and Sensor Fusion (2021)

Authors: Wang, L., Zhang, Y., & Liu, G.

The authors created a sophisticated fault diagnosis system for industrial robotic arms. By integrating data from motor encoders, strain gauges, and thermal cameras, their deep learning model can predict and identify mechanical and electrical faults with high precision. The system excels at diagnosing issues in complex electromechanical systems, which is applicable to many interactive exhibits. However, it is designed for a controlled industrial setting with predictable operational cycles. It is not adapted to the chaotic and unpredictable nature of public interaction in a museum, nor does it account for software-related failures that are common in digital exhibits.

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5. A Visual Inspection System for Surface Defects in Complex Manufactured Components Using Generative Adversarial Networks (2023)

Authors: Singh, A., & Gupta, R.

This paper proposes a novel visual inspection system that uses Generative Adversarial Networks (GANs) to create synthetic defect data for training a robust detection model. This allows the system to identify a wide range of surface imperfections on complex industrial components with limited real-world training data. The use of GANs is a significant step toward creating more adaptable and data-efficient inspection systems. Nevertheless, its application is confined to detecting cosmetic and surface-level flaws in a manufacturing context. It lacks the capacity for the functional, multi-modal monitoring required to assess the operational health of an interactive science exhibit.

How My Project Goes Further

While the projects mentioned above provide a strong foundation in AI-based fault detection for static structures and industrial machinery, a significant gap remains in the real-time, holistic monitoring of interactive science museum exhibits. My project advances this field by creating a system that specifically addresses the unique challenges of a public learning environment. It will innovate by fusing visual data with non-visual sensor data and software logs to create a comprehensive understanding of an exhibit's health. By leveraging models like CNNs and YOLOv5 for visual inspection and employing machine learning to analyze data from a suite of integrated sensors, this project will provide a real-time, multi-modal monitoring solution. The system will not only detect physical damage but also identify functional, software, and user-centric problems, presenting this information through an actionable dashboard for museum staff. This will enable proactive maintenance, reduce exhibit downtime, and ensure a seamless and engaging visitor experience in a way that current systems cannot.

Problem Identification

Science centers and other public educational institutions greatly rely on interactive exhibits for interactive, hands-on learning experiences. These facilities, however, continually have demanding and problematic operational challenges:

1. High Exhibit Failure Rate

• Modern Exhibit Sophistication: Modern exhibits have a lot of moving parts, electronic displays, sensors, and software. The sophistication raises the risk of failure, ranging from mechanical to software crashes and sensor malfunctions.

• Patterns of Use: Screens are subject to repeated, random use by individuals of all ages, accelerating wear and tear and making breakdowns unpredictable or impossible to prevent through regular maintenance alone.

2. Insufficient Real-Time Monitoring

• Staffing Constraints: Museums generally have limited technical personnel, so it is not feasible to have someone monitoring each exhibit manually all day long.

• Late Detection: The defects remain undetected for extended periods, particularly at times of high usage or in large galleries, and result in prolonged downtime.

3. Detriment to Visitor Experience and Institutional Reputation

• Visitor Frustration: Frustration with non-working or damaged exhibits results in disappointment, interrupts the learning process, and could have a negative overall impact on visitors' perceptions of the museum.

• Reputational Risk: Ongoing technical problems may tarnish the reputation of the museum as a dependable, forward-thinking, and consumer-friendly institution, potentially affecting visitor attendance and community goodwill.

4. Operational Inefficiencies

• Manual Checks Take Time: Routine manual checks are time-consuming, not reliable, and divert manpower from other core operations.

• Reactive Maintenance: Reactive maintenance and not proactive, in which the repairs are only done after the failure has been identified, thus causing unnecessary downtime and increased operating costs.

5. Absence of Data-Driven Maintenance

• Lack of Analytics: Without frequent data gathering on exhibit performance and failure patterns, museums miss the opportunity for predictive maintenance, resource planning, and strategic planning.

• No Centralized Tracking: Exhibit health and maintenance histories are seldom tracked centrally and conveniently, making long-term improvement and accountability difficult.

In brief:

Lack of a smart, automated monitoring and alert system for exhibit well-being leads to repeated undetected failures, wasteful maintenance, and reduced visitor satisfaction. An intelligent, AI-based solution for ongoing monitoring of exhibit operation, automatic notification of staff of problems, and actionable intelligence is clearly needed, enabling safe operation, enhanced visitor experience, and enhanced institutional standing.

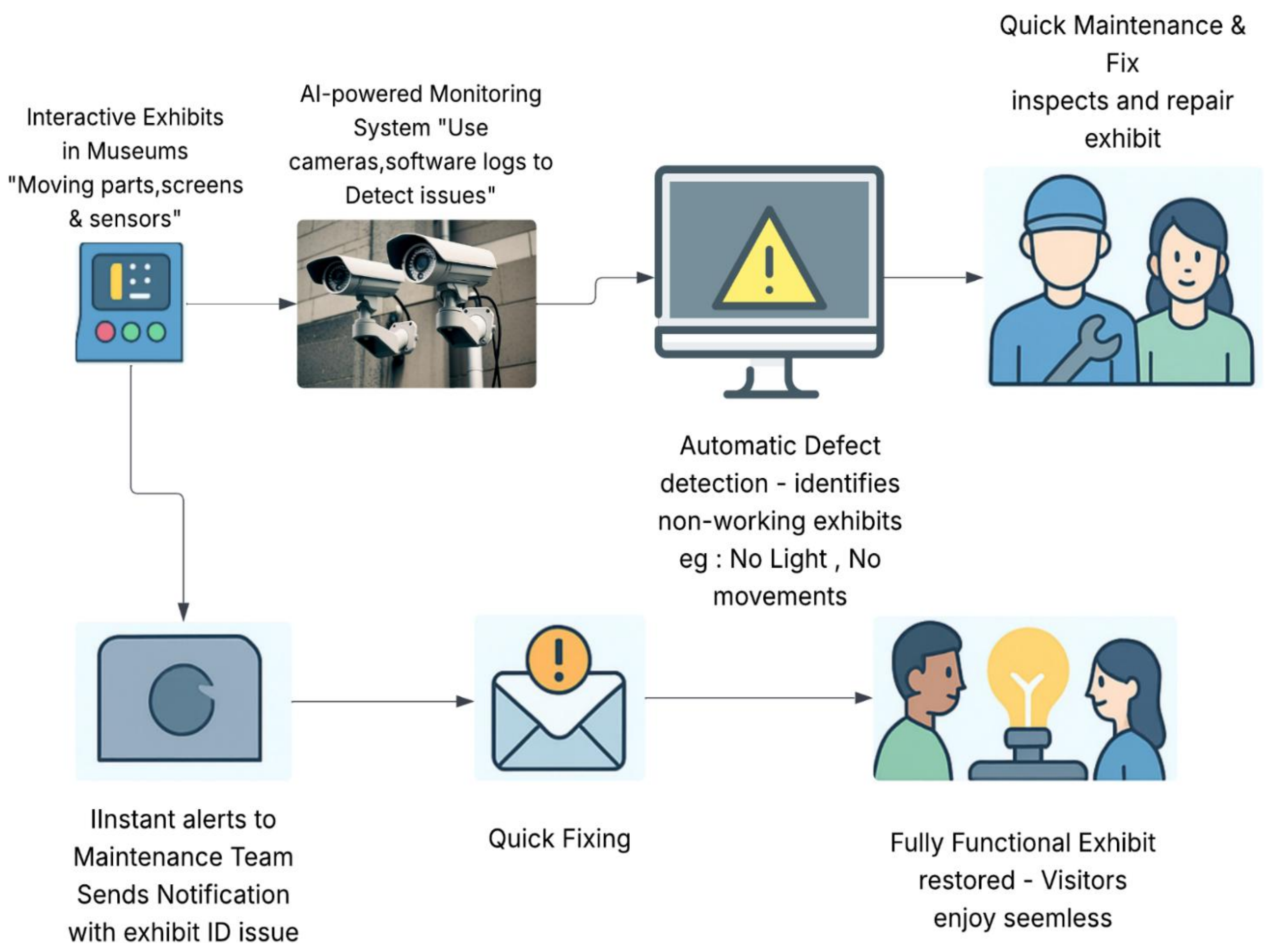
Proposed Solution

The project proposes a combined platform using AI-powered video inspection, IoT sensors, and software logging to detect immediately non-operational or defective exhibits automatically. Once a defect is detected, the platform notifies the maintenance personnel in real time via a dashboard and mobile alerts. The platform also maintains maintenance history and provides analytics of the status of the exhibits to enable data-Driven decision making for preventive maintenance and resource scheduling.

Methodology

This methodology describes the systematic approach for developing and deploying an AI-based system to automatically detect defective science museum exhibits. By integrating cameras, sensors, and intelligent algorithms, the project aims to ensure continuous exhibit functionality, reduce downtime, and enhance the visitor experience.

- **Interactive Exhibits**
  Science museum displays are equipped with moving parts, screens, sensors, and embedded control systems.
- **Cameras & IoT Sensors**
  Devices installed on or near exhibits to continuously capture visual data and operational metrics (e.g., motion, temperature, touch response).
- **Data Acquisition Unit**
  Centralized hardware or edge devices that collect, aggregate, and preprocess data streams from all sensors and cameras.
- **AI/ML Model**
  Deep learning algorithms (such as CNNs or YOLO) are trained to analyze images and sensor data, identify malfunctions, and classify defect types in real time.
- **Alert & Notification System**
  Automated software that instantly notifies maintenance staff via dashboard, SMS, or mobile app when a defect is detected.
- **Maintenance Dashboard**
  A user-friendly interface displaying real-time exhibit status, fault history, and analytics for maintenance planning and decision support.



Interactive Exhibits
in Museums
"Moving parts,screens
& sensors"
AI-powered Monitoring
System "Use
cameras,software logs to
Detect issues"
Quick Maintenance &
Fix
inspects and repair
exhibit
Automatic Defect
detection - identifies
non-working exhibits
eg : No Light , No
movements
IInstant alerts to
Maintenance Team
Sends Notification
with exhibit ID issue
Quick Fixing
Fully Functional Exhibit
restored - Visitors
enjoy seemless

Methodology

Development of an AI-based automated Defective Exhibit Identification System In science museums begins with the installation of cameras and IoT sensors on or near interactive exhibits to tracking their working status continuously. Visual and sensor data streams are streamed in real time to a centralized data acquisition system, where they are preprocessed for analysis. Deep learning algorithms—e.g., convolutional neural networks (CNNs) or YOLO object detection models—are trained to recognize patterns indicative of exhibiting malfunctions, e.g., mechanical failure, screen faults, and sensor faults. The AI models process incoming data to detect anomalies and classify defect types. When a fault is detected, the system automatically sends alerts and notifications, which are routed to the maintenance team via a dedicated dashboard and mobile app. The dashboard also logs maintenance activities and provides analytics on exhibit health and downtime trends, enabling data-driven preventive maintenance and operational optimization. This integrated process enables rapid defect identification, minimizes exhibit downtime, and enhances the overall visitor experience.

Work Plan

S.No	Work Description	Duration
1	Project Analyzing	2 Months
2	Data Collection	
3	Material Selection and Purchasing	2 Months
4	Project Prototype completion	3 Months
5	Testing	
6	Project Report Preparation & Submission	20 Days

Budget

PARTICULAR/ITEM	Total idea project cost (Rs. In Lakh)
Technology, Materials, Testing & Development	10.00
Charges for mentor/handholding supporting team Max (3.00) lakh	3.00
Travelling Expenses or any other item not covered as above may be allowed as per need for development of the idea Max (2.00) lakh	2.00
Total	₹15 lakh

Newness and Uniqueness of Solution

The solution proposed here presents a fresh, AI-based methodology for the maintenance of science museum exhibits by combining real-time visual analytics with IoT sensor data. Unlike conventional systems based on periodic manual checks or one sensor warnings, this solution uses sophisticated deep learning algorithms to continuously monitor exhibit health, identify a broad spectrum of faults in real-time—mechanical, electronic, and software—and automatically alert maintenance staff. One of the distinguishing features is the system's capability to aggregate multi-modal information (camera feeds, sensor data, software logs) to perform end-to-end, context-aware fault detection. The easily accessible dashboard not only offers real-time status information and alerts but also maintains a record of maintenance activities and analyzes historical trends to support predictive maintenance and planning for resources. This proactive automated monitoring prevents small exhibit downtime and promotes ultimate visitor satisfaction. Furthermore, the flexibility of the system allows it to be customized to suit various types of exhibits and scaled to various institutional sizes. Through closing the gap between industrial AI solutions and science museum operational requirements in the public sphere, the solution creates a new benchmark for intelligent, sustainable, and visitor-centric exhibit management—a previously unattained innovation in this area.

Concept and Uniqueness of the Solution

The core concept here is to implement an intelligent, self-sufficient system that is always keeping watch on the operational condition of interactive science museum exhibits using a combination of cameras and IoT sensors. Traditionally, exhibit maintenance relies on regular human inspections or user reports, leading to fault detection delays, unwarranted downtime, and degraded visitor experience. This project envisions replacing such reactive and manual approaches with a proactive, AI-driven system leveraging real-time visual and sensor data. Utilizing deep models of learning—such as convolutional neural networks (CNNs) and object detection models such as YOLO—the system can accurately identify a wide variety of exhibit faults, from mechanical issues to display issues and sensor faults. If any anomaly is detected, the system automatically notifies the maintenance team through automated alerts and updates a centralized dashboard tracking exhibit health and maintenance operations.

What sets this solution apart is its comprehensive, data-driven approach:

It integrates multi-modal streams of data (visual, sensor, and software logs) for end-to-end fault detection, beyond the capabilities of single-sensor or manual methods.

The platform not only detects and classifies faults in real time but also provides actionable analytics for preventive maintenance, resource planning, and long-term operational optimization. Its modular architecture facilitates ease of customization and scalability for different types of exhibits and museum sizes, ensuring responsiveness to diverse institutional needs. Where AI-based defect detection has seen growth in industrial and manufacturing applications, its application-specific design for interactive, public-access science exhibits is new. This solution paves the way for applying advanced AI and IoT technologies to optimize exhibit uptime, enhance visitor experiences, and optimize museum operations, setting a new standard for smart facility management in the cultural and educational sectors.

Specify the potential areas of application in industry/market in brief

The applications of this AI-based automated defective exhibit detection system are wide-ranging across industries. For the museum and cultural heritage sector, it provides uninterrupted, seamless operation of interactive exhibits, maximizing visitor experience and learning opportunities. Science and technology museums can minimize exhibit downtime and maintenance expenses by implementing this proactive monitoring system. Outside the museums, theme parks and edutainment centers with intricate interactive installations can use this technology to ensure high operational quality and improve visitor satisfaction. Corporate experience centers and innovation centers can implement the system to ensure faultless demonstrations of their products and technologies. Smart public spaces—such as digital kiosks, information boards, and interactive displays in airports, malls, and exhibitions—can also utilize real-time fault detection and maintenance alerts, reducing service downtime. The scalability and adaptability of this solution make it suitable for any configuration where interactive technology and visitor experience are critical, maximizing operational efficiency and maximizing user interaction across industries..

Briefly provide the market potential of the idea/innovation

Market potential for AI-Based Automated Defective Exhibit Identification System is strong, driven by the increasing adoption of interactive exhibits in science museums, theme parks, and education centers around the world. As museums compete to deliver improved visitor experiences and operational performance, smart maintenance solutions that reduce downtime and lower the cost of manual inspection are in greater demand. The increasing adoption of IoT and AI technologies in public spaces further widens the market potential for automated defect detection systems. Scalability and flexibility of the solution resonate with a broad range of industries, including corporate experience centers, smart buildings, and public digital kiosks. With growing emphasis on visitor satisfaction and cost-incurred facility management efficiency, the innovation is well-positioned to capture growing market share for smart maintenance and operational excellence.