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|  | **SMART PART VERIFCATION IN AUTOMOTIVE MANUFACTURING PLANT** |  |
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| Stage | Activity | Tool | Outcome |
| Stage I: Brainstorming | Group Discussion on requirements and solution model Challenges – Misidentification of parts, improper installations, manual verification delays  Opportunities – Real-time defect detection, predictive maintenance using ML models  Ideas – Extendable to full vehicle assembly audit, AI-based adaptive learning for defect types    FLASH CARD Type: Industry 4.0, Smart Manufacturing Domain: Automotive Quality Assurance & Process Optimization Stakeholders: Line supervisors, Plant QA teams, OEMs, Automation teams Technologies: PIR, IR, and Color sensors, MQTT, Cloud Computing, Machine Learning, Dashboards | A Smart Part Verification System for automotive manufacturing plants that can: (i) detect the presence of parts using PIR and IR sensors (ii) verify part type and color using a color sort sensor (iii) transmit sensor data to the cloud using MQTT (iv) analyze data with machine learning models to detect incorrect/missing parts (v) visualize insights and trends through dashboards for root cause analysis (vi) trigger real-time alerts for manual or robotic intervention to ensure minimal downtime and improved quality |
| Stage II: Idea Posting |  | In modern automotive manufacturing, ensuring the correct installation of parts is critical to maintaining product quality and minimizing rework. This project presents a smart part verification system using a combination of PIR (Passive Infrared), IR (Infrared), and Color Sort sensors to detect the presence, type, and color of components on the assembly line. The sensor data is transmitted to the cloud using the MQTT protocol, where machine learning models and analytics pipelines process it to identify installation defects such as missing parts, mismatches, or incorrect placements.  The system incorporates real-time dashboards that visualize defect trends and support root cause analysis. By generating instant alerts for human or robotic intervention, the solution enhances operational efficiency, reduces downtime, and minimizes production errors. This intelligent verification framework contributes significantly to automation and quality assurance in automotive assembly environments. |
| Stage III: Customer  Mapping | 1. For Assembly Line Operators  * What issues do you face with missing or incorrect part installations? * How often do you manually inspect part placements?  1. For Quality Assurance (QA) Inspectors  * How do you currently verify part type and color? * What accuracy level do you expect from an automated system?  1. For Maintenance Engineers  * How do you identify faulty sensors or system failures? * Would predictive maintenance alerts improve your workflow?  1. For Automation & Robotics Teams  * Do you need real-time alerts for robotic intervention? * How should sensor data integrate with your existing control systems? | Requirement Specification from Customer Mapping  **Assembly Line Operators** require a system that immediately detects missing/incorrect parts and reduces dependency on manual verification.  **Quality Assurance Inspectors** need highly accurate verification of part presence, type, and color for compliance and quality reporting.  **Maintenance Engineers** want the system to support predictive maintenance by identifying potential faults in sensors or communication.  **Automation Teams** need seamless MQTT-based data flow and real-time alerts for initiating robotic corrections without human delay. |
| Stage IV:  Idea Layout |  | This Smart Part Verification system for automotive manufacturing integrates hardware sensors with intelligent software to ensure accurate part installation and reduce rework. The system uses **PIR, IR, and color sensors** to detect part presence, verify correct seating, and confirm component color. These sensor inputs are processed locally using **edge computing**, enabling **real-time alerts** and operator feedback through a **simple dashboard**. This ensures quick error detection and immediate corrective actions on the production line.  On the data side, the system tracks **installation errors**, maintains **quality records** linked to each vehicle's VIN, and performs **trend analysis** to identify recurring issues. The implementation strategy emphasizes a **start-small approach**, incorporating **operator feedback** and minimizing disruption to existing processes. Looking ahead, the system can be extended into the **supply chain** for verifying supplier parts and implementing **predictive quality** measures to anticipate failures before they occur, further enhancing operational efficiency and reducing manufacturing defects. |
| Stage V: Reflection | A detailed checklist was used to assess the completeness, system functionality, deployment readiness, and user interaction capabilities of the Smart Part Verification System.   Key Evaluation Areas: **System Functionality**: Presence of PIR, IR, and Color sensors; reliable MQTT-based data transmission; effective ML integration for mismatch and defect detection; real-time dashboards; alert mechanisms. **Implementation Readiness**: Compatibility with existing assembly lines; adaptable ML model; basic fallback for cloud failure; stakeholder workflow integration.  **User Interaction**: Dashboard usability for QA teams; actionable mobile alerts; supervisor training. | • The ML system lacks **real-time adaptive learning**, limiting its ability to evolve with new defect patterns. • There's an **over-dependence on continuous cloud connectivity**, risking alert failures during outages. • The system lacks a **local fallback mechanism** for analytics and alerts when connectivity fails. • A **structured feedback loop** from line operators for improving system accuracy is missing. • **Scalability** remains a concern, especially when extending the solution plant-wide or integrating with complete vehicle audit systems. |
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