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SmartLab: AI-Based College Laboratory Equipment Tracking and Predictive Maintenance System

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Abstract

College laboratories contain equipment that must be identified, tracked, and maintained to support practical learning. Manual registers and periodic inspections can make it difficult to know the current status of each item, find maintenance history quickly, and identify equipment that may need servicing. SmartLab proposes a software-based system for registering laboratory equipment, tracking its status, maintaining service records, and using equipment usage and maintenance history to estimate maintenance needs. The application provides a staff dashboard for equipment registration, tracking, maintenance updates, and reports. Equipment can be assigned a unique ID and a status such as Available, In Use, Faulty, or Under Maintenance. A predictive-maintenance module can analyse recorded usage and service history to flag equipment for inspection. The system is intended to improve record accessibility, support timely maintenance, and reduce avoidable disruption in college laboratories. Predictions are decision-support suggestions and should be verified by laboratory staff.

Keywords: SmartLab, laboratory equipment tracking, predictive maintenance, artificial intelligence, equipment management, maintenance history.

I. INTRODUCTION

Laboratory equipment is essential for practical sessions, experiments, and student projects. When equipment information is maintained in separate registers or spreadsheets, staff may spend extra time checking availability, locating items, and reviewing past repairs. Equipment faults may also be discovered only after a problem occurs or during a scheduled inspection.

SmartLab is designed as a centralized software application for laboratory staff. It stores equipment details, displays current status, records maintenance activities, and produces reports. The proposed AI-based component uses available usage and maintenance records to identify patterns that may indicate a need for service. This approach combines routine tracking with data-supported maintenance planning.

II. PROBLEM STATEMENT

A manual or disconnected equipment-management process can lead to outdated status information, incomplete maintenance records, delays in locating equipment details, and difficulty planning preventive service. The project addresses the need for a simple centralized system that helps staff track laboratory assets and identify equipment that may require attention.

III. OBJECTIVES

- Develop a software application for registering and managing college laboratory equipment.
- Assign a unique Equipment ID and store equipment name, category, laboratory location, purchase date, and status.
- Track equipment using the statuses Available, In Use, Faulty, and Under Maintenance.
- Maintain service records containing maintenance date, reported problem, repair details, and next service date.
- Use recorded usage and maintenance history to flag possible maintenance needs.



- Provide a dashboard and reports to help laboratory staff make timely, informed decisions.

IV. RELATED WORK / LITERATURE REVIEW SUMMARY

Equipment-management systems commonly use asset registers, unique identifiers, status fields, and service logs to improve record keeping. Computerized maintenance-management approaches organize work orders, repair history,

and scheduled service. Predictive-maintenance research uses operational data and historical failures to estimate the likelihood that equipment will need attention. For a college mini-project, these ideas can be combined in a lightweight application.

The effectiveness of a predictive model depends on the quality, quantity, and consistency of historical data. If a laboratory has limited failure records, the initial version should use transparent rules or simple indicators and label the output as a maintenance alert rather than a guaranteed failure prediction. The model can be improved as reliable records accumulate.

V. PROPOSED SYSTEM ARCHITECTURE

The proposed application can be organized into the following connected modules:

Input Staff login and equipment details
↓
Equipment Management Register, edit, search, and track equipment
↓
Maintenance Records Log faults, repairs, service dates, and usage history
↓
Prediction / Alert Module Rules or an ML model flags items needing inspection
↓
Dashboard and Reports Current status, upcoming service, and maintenance summaries

1. Login module: Provides access to authorized laboratory staff. **2. Equipment module:** Stores and updates equipment details. **3. Tracking module:** Shows the latest status and location. **4. Maintenance module:** Stores fault and repair history. **5. Prediction module:** Uses usage/service information to generate maintenance alerts. **6. Reports module:** Summarizes equipment status and service activity.

VI. METHODOLOGY

The development process can follow these steps:

- Requirement collection: identify the information laboratory staff need to record and view.
- Database design: create equipment, user, usage, and maintenance-record tables with unique identifiers.
- Interface development: create login, equipment registration, equipment tracking, maintenance, and reports pages.
- Record management: validate required fields and save status changes and service history.
- Predictive-maintenance logic: begin with service-due rules or simple analysis of usage and repair history; use a trained ML model only when sufficient labelled data is available.
- Testing: verify registration, search, status updates, maintenance logging, access control, and report generation.
- Evaluation: measure record completeness, time needed to find equipment information, alert usefulness, and prediction performance when labelled data exists.



VII. EQUIPMENT DATA AND SYSTEM OUTPUT

Field	Example / purpose
Equipment ID	Unique identifier for each item
Equipment name / category	Name and type of laboratory asset
Lab location	Building, room, or lab where the item is kept
Status	Available / In Use / Faulty / Under Maintenance
Maintenance record	Date, problem, repair performed, next service date
Usage history	Recorded use or operating hours, if available

The main outputs are a searchable equipment list, current-status dashboard, equipment history, maintenance schedule, and alerts for items that may need inspection. An alert is not a substitute for physical inspection or staff judgement.

VIII. ADVANTAGES

- Centralizes equipment details and maintenance history.
- Makes it easier to check availability and location.
- Helps staff identify faulty items and upcoming service tasks.
- Reduces repeated manual searching and improves record consistency.
- Provides a foundation for future data-driven maintenance planning.

IX. LIMITATIONS

- Prediction quality depends on the availability and accuracy of usage and repair data.
- A new laboratory system may not have enough historical failures to train a reliable ML model.
- Incorrect or delayed status updates can make dashboard information outdated.
- The application requires suitable access control, backups, and regular maintenance.
- Maintenance alerts must be checked by laboratory staff before action is taken.

X. TESTING AND EXPECTED OUTCOME

The project should be tested with sample laboratory equipment records. Functional tests should check whether staff can log in, add and edit equipment, search by ID or name, update status, save a maintenance record, and view reports. Predictive alerts should be checked against known service dates or labelled historical cases when such data is available.

Expected outcome: a working prototype that organizes equipment records, provides current status information, and supports maintenance planning. No measured accuracy or performance result is claimed in this report; these values should be added after implementation and testing.

XI. FUTURE SCOPE

- QR-code or barcode scanning for faster equipment identification.
- IoT sensors to collect operating hours or condition readings automatically.
- Machine-learning models trained on verified historical maintenance data.
- Email or in-app notifications for service due dates and fault reports.
- Role-based access, audit logs, backup, and exportable reports.
- Expansion to multiple departments, laboratories, or campuses.

XII. CONCLUSION

SmartLab proposes a practical software solution for college laboratory equipment tracking and predictive maintenance. By combining a centralized equipment register, status tracking, service history, dashboard, and maintenance alerts, the system can help laboratory staff organize information and plan inspections more effectively. Its predictive component should be introduced



carefully, using reliable records and clearly communicating uncertainty. The project can be extended with QR codes, sensor data, and machine-learning models as the amount and quality of data improve.

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