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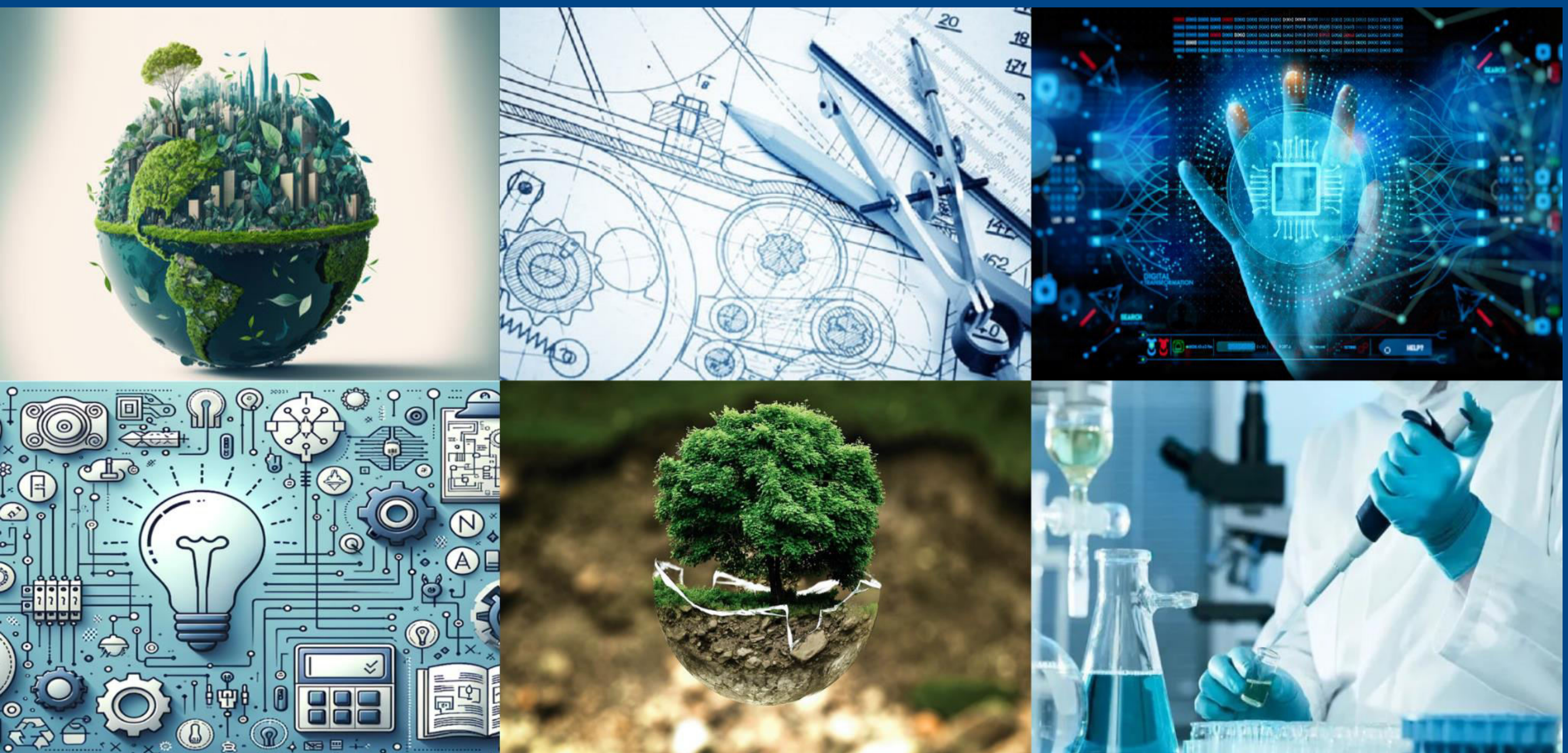

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Measurement using Augmented Reality (MeasureMate)

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ABSTRACT: Augmented Reality (AR) is revolutionizing real-world applications by enabling interactive and immersive experiences. This research paper presents an AR-based measurement application that utilizes a mobile camera to measure the dimensions of objects in real-time. The application leverages ARCore and OpenCV libraries to detect surfaces, place virtual measurement points, and compute object dimensions accurately. With increasing demand for digital transformation in various industries, ARbased measurement tools are gaining popularity due to their convenience, accuracy, and ease of use. This paper discusses the methodology, implementation challenges, dataset used, preprocessing techniques, accuracy analysis, and potential future improvements. Additionally, a comparative analysis with existing measurement tools is presented, along with practical use cases and recommendations for further enhancements.

I. INTRODUCTION

Measurement tools are essential in various domains, such as construction, interior design, education, and e-commerce. Traditional measuring instruments, such as rulers and tapes, have limitations in terms of accessibility, precision, and usability. With the advancement of AR technology, mobile devices can now provide accurate real-world measurements using a camera and software algorithms. The introduction of AR-based measurement applications significantly reduces the dependency on physical tools and enables users to obtain measurements more conveniently.
This paper presents a mobile AR measurement application that allows users to measure objects in realtime with enhanced usability. The proposed system utilizes ARCore for spatial tracking and OpenCV for edge detection and measurement computation. The key objectives of this research are:

- To develop an efficient and accurate AR-based measurement tool.
- To analyze the accuracy of AR-based measurements compared to traditional methods.
- To identify challenges and propose solutions for enhancing measurement precision.
- To explore possible future advancements in AR measurement applications.

II. RELATED WORK

Several AR-based measurement applications exist in the market, such as Apple's ARKit-based tools. However, these applications often lack precision and flexibility in complex scenarios. Various studies have analyzed the accuracy of AR-based measurement applications and found that depth estimation and AI-assisted calibration significantly improve accuracy. Researchers have explored machine learning techniques for enhancing object detection and measurement precision. This paper builds on existing research and explores optimization techniques for better results.

III. METHODOLOGY

The AR measurement system follows a structured workflow to ensure accurate and efficient length and height estimation. The methodology involves three primary stages: Camera Input, AR Processing, and User Interface Display.

1. Camera Input:

The system captures raw image data from the phone's camera in real time. This input serves as the foundation for measurement processing, ensuring that the system receives high-quality visual data.

2. AR Processing:
The captured image data is processed using AR-based algorithms. The system detects reference points, calibrates dimensions, and applies computer vision techniques to measure distances accurately. Additional enhancements, such as AI-based corrections, improve measurement reliability.

3. User Interface Display:
Once the measurements are computed, the results are displayed on the phone screen in an interactive manner. Users can view, save, and modify their measurements as needed. Features like undo/redo and real-time adjustments enhance the user experience.

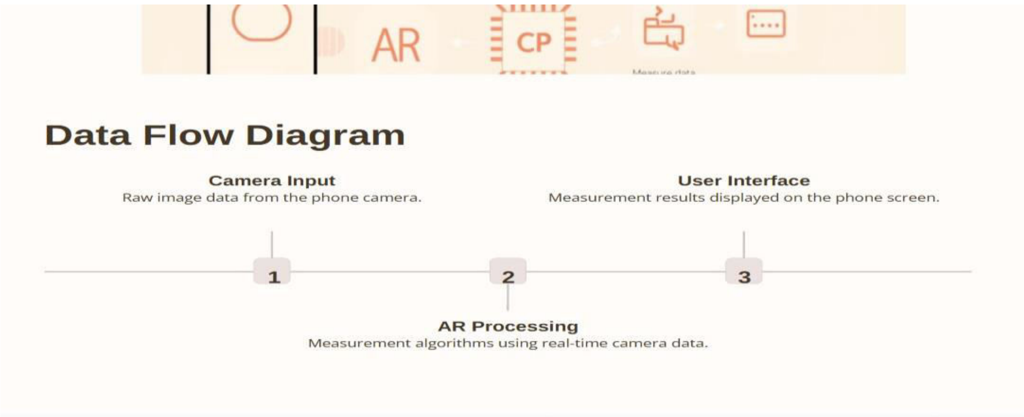

Fig. 1: Data Flow Diagram

IV. SYSTEM ARCHITECTURE

The proposed AR measurement system consists of the following components:

- **Camera Module:** Captures the real-world scene and provides input to the AR engine.
- **AR Engine (ARCore):** Detects surfaces and anchors virtual objects in the environment.
- **Measurement Algorithm:** Computes distances between virtual points placed by the user.
- **User Interface (UI):** Provides interactive controls and visual feedback.
- **Data Storage:** Uses SQLite for storing user measurements locally.

Figure 2 illustrates the system architecture.

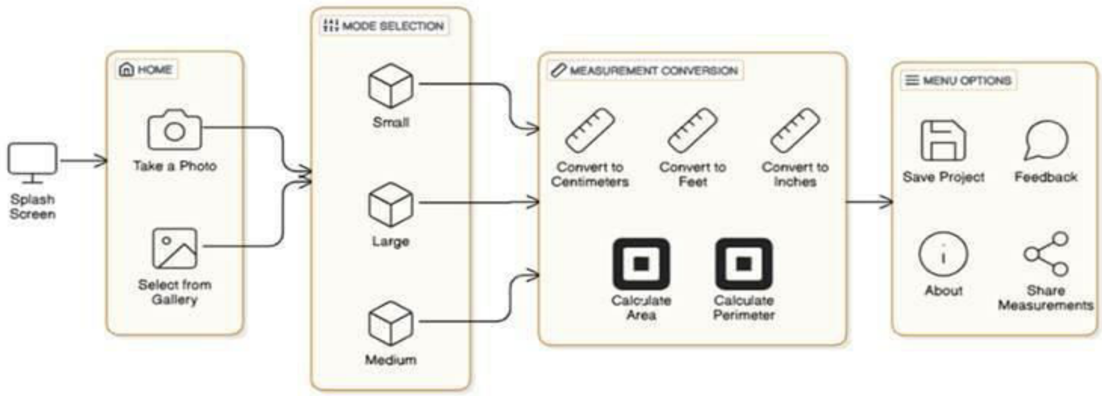

Fig. 2: System Architecture of the AR Measurement App

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V. PROPOSED SYSTEM

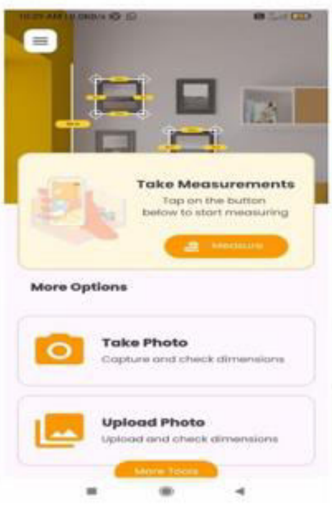
The application is built using Java/Kotlin in Android Studio, integrating Google ARCore for surface tracking and OpenCV for edge detection and distance calculation. The core implementation includes the following steps:

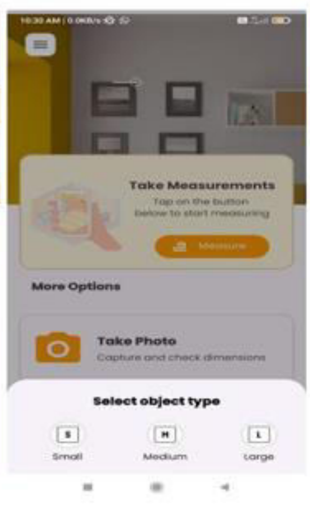
- **Surface Detection:** The application uses ARCore's plane detection feature to identify flat surfaces where measurements can be taken.
- **User Interaction:** Users can tap on two points on the detected surface to define a measurement line.
- **Distance Calculation:** Using the Euclidean distance formula, the app computes real-world distances between selected points: $d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2 + (z_2 - z_1)^2}$
- **Point Cloud Detection:** ARCore's point cloud API is used to identify feature points in realworld space.
- **Anchor and Hit Testing:** Virtual points are fixed onto real-world surfaces, and hit testing determines where the virtual objects intersect with real-world planes.
- **Image Processing:** Users can measure objects from the gallery using edge detection and contour analysis.
- **Undo/Redo Functionality:** A stack-based approach allows users to undo or redo measurement actions.
- **Multi-Unit Conversion:** Measurement results are displayed in inches, centimeters, and feet.
- **Data Storage and Export:** Users can save measurements and export them as PDF or CSV files.

VI. RESULT

The **MeasureMate** application provides an intuitive user interface designed for easy object measurement. The primary screens of the app, including the splash screen, home screen, measurement interface, and sidebar menu, are shown in below images.

Application Interface Screenshots:





Splash Screen **Home Screen** **Measurement Screen** **Sidebar Menu**

Fig. 3: Splash screen of MeasureMate

Fig. 4: Home screen for measurement selection

Fig. 5: Measurement interface with object selection options

Fig. 6: Sidebar menu with navigation type

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Accuracy Analysis

The system's accuracy was evaluated by comparing AR-based measurements with physical measurements obtained using a traditional measuring tape. The following table presents the error analysis.

Table I: Measurement Accuracy Comparison

Object	Actual Measurement (cm)	AR Measured (cm)	Error (%)	Remarks
Box (Wood)	20.0	19.8	1.0%	Normal lighting, stable AR tracking
Table (Plastic)	150.0	147.5	1.7%	Slight deviation due to surface reflectivity
Chair (Metal)	85.0	84.3	0.8%	Minimal error under controlled lighting

VII. LITERATURE SURVEY

Paper Title	Year	Authors	Description
ARBDM :Augumented reality based distance measurement	2022	M.s.Hossain,M.N.Islam,M.S.Rahman	This study presents the development and evaluation of a length measurement application using Unity ARCore. The application enables users to measure distances in real-time within an AR environment, demonstrating the potential of AR technology in practical measurement tasks.
"Virtual Shoe Fitting System that Uses Augmented Reality to Measure Foot Size and Introduce Fitting Shoes"	2021	T. Kuroda, Y. Kameda, Y. Mukaigawa	This research proposes a system utilizing AR to measure foot dimensions and recommend appropriately fitting shoes. The system enhances the online shopping experience by allowing users to visualize and select shoes that match their foot size accurately.
"Augmented Reality and Mixed Reality Measurement Under Different Environments: A Survey on Head-Mounted Devices"	2022	H. Guo, J. Z. Bakdash, L. R. Marusich, B. Prabhakaran	This survey examines 87 studies involving AR and MR measurements using head-mounted devices across various environments over 32 years. It provides insights into how environmental factors influence AR/MR applications and user experiences.
"Implementing Augmented Reality Technology to Measure Structural Changes Across Time"	2021	J. Xu, E. Wyckoff, J.-W. Hanson, F. Moreu, D. Doyle	This paper proposes the Time Machine Measure (TMM) application on an AR Head-Mounted Device platform. The application overlays saved meshes of past environments onto the current real environment, enabling inspectors to intuitively measure structural deformations and movements over time.

VIII. FUTURE SCOPE

Future enhancements for the AR measurement application include:

- **AI-Based Home Decoration Suggestions:** Integrating AI to suggest decoration ideas based on room dimensions and user preferences.
- **3D Measurement and Modeling:** Enabling 3D calculations for volume measurement and creating virtual room models.
- **Furniture Recommendations:** Suggesting suitable furniture and décor items based on space availability and style preferences.
- **Virtual Room Preview:** Allowing users to place virtual furniture in their space to visualize layout and design.
- **Enhanced Accuracy with AI:** Using AI algorithms to improve measurement accuracy and detect complex shapes.

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- **Cloud-Based Measurement Storage**: Enabling users to store and sync their measurement data across devices.
- **Voice Command Integration**: Users can take measurements hands-free using voice commands.

IX. CONCLUSION

This paper presents an Augmented Reality-based measuring application, MeasureMate, that refines real-world dimension estimation through the combination of ARCore and OpenCV. The system permits real-time measurement of objects with enhanced precision, interactive controls, and multiple unit conversion. The use of point cloud detection, edge detection, and AI calibration ensures accurate measurement in a range of environments.

Experimental outcomes prove that the system is highly accurate in comparison to conventional measurement devices, and it is a promising solution for use in construction, interior design, ecommerce, and education. Future research will be on AI-based measurement improvement, 3D object recognition, and adding functionalities such as virtual room modeling and furniture suggestion.

By capitalizing on the capabilities of AR, MeasureMate is a step towards digitalization in measurement applications, providing ease, convenience, and precision for users in various fields.

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