Augmented Reality-Based Business Cards on

Android Devices for LPU-Cavite with Optimized

Tracking using Kalman Filter Algorithm

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*Abstract*— This study introduces PartnAR, an Augmented Reality-based business card application designed to help employees connect more effectively with potential partners, collaborators, or clients through engaging business card presentation by optimizing AR tracking using Kalman Filter Algorithm. The system allows dynamic updates of employee and university information through a content management system, maintaining relevance and enhancing professional credibility. With an RMSE of 0.05, tracking jitter of 0.07, detection rate of 88.56%, and processing time of 0.000134 seconds per frame, the evaluation showed that the standard Kalman Filter algorithm produced the best performance. These findings imply that the Kalman Filter performs well in real-time augmented reality applications while successfully maximizing tracking and noise reduction. The functionality and compatibility testing yielded a result of 100% pass rate across 135 test cases, wherein the CMS and mobile application received a rating of “Highly Acceptable” based on the ISO/IEC 25010 model (grand mean: 3.52) and MARS (grand mean: 3.59) respectively. The final evaluation, which involved different roles such as employees, administrators, IT Experts, and HR personnel from external companies showed a strong support to the usefulness, aesthetic appeal, and potential of the system for enhancing professional networking. The recommendations include allowing user-uploaded models through the CMS, improving text recognition accuracy, adding iOS support, and storing 3D models in the cloud.

Keywords—AR Business Card Application, Augmented Reality, Content Management System, Kalman Filter Algorithm, User Engagement and Interaction.

# Introduction

Augmented Reality is one of the technologies that continue to revolutionize many industries by connecting the physical and digital world. AR continues to be adopted in various fields such as education, marketing, and networking. Augmented Reality serves as a tool for developing an engaging and interactive experience to draw the attention of potential patrons [1]. Moreover, AR contributes to brand awareness and customer interaction by overlaying digital versions of products and services in the physical world [2]. AR has become a valuable medium has provided several solutions for engagement and communication, which gives advantage to universities and its employees by providing an interactive approach for conveying information [3].

Business cards have long served as an affordable yet powerful marketing tool, enabling small businesses and freelancers to enhance visibility and forge new connections in face‑to‑face environments. A study from Ponomarenko and Uhnivenko highlight how thoughtfully designed branding elements on business cards not only distinguish a company’s identity but also act as a catalyst for interpersonal engagement and trust building. By exchanging cards, individuals extend their professional networks and maintain a tangible reminder of each interaction an essential first step in cultivating long‑term relationships and opening channels for future collaboration [12].

Building on this foundation of personal outreach, modern institutions have begun to view all stakeholders both external clients and internal staff through a unified lens of relationship management. Cortiñas (2020) argues that treating faculty and staff as “internal customers” and engaging them through participative leadership approaches fosters a culture of ownership and commitment, which, in turn, elevates service quality and institutional brand value [14]. In parallel, the integration of augmented reality (AR) into media art and marketing contexts promises to further enhance these connections by superimposing dynamic digital content onto the physical world [13]. However, seamless virtual–real fusion demands precise tracking and stability: the Kalman filter algorithm is instrumental here, filtering out noise to deliver accurate, stable overlays that enrich user experience and strengthen the bridge between collaborators, audiences, and institutional stakeholders [15]. AR applications with high marker tracking and accuracy are important to provide smooth experience to potential users [16].

Traditional business cards are used for conveying static information to clients and customers. However, this poses a significant disadvantage as it lacks a dynamic approach for updating information, thus resulting in high costs and inefficiency. Printing costs serve as one of the significant issues in physical cards since changing designs and information can lead to increased expenses [4]. Scalability play an important role to make content management simpler for users across different platforms [17].

The use of AR is influential in various fields. As such, it is appropriate to be applied in multimedia as it will enhance the engagement and effectiveness in conveying information [18]. Digital transformation can offer a new way of sharing information in a more interactive format [19].

The researchers conducted a survey among 39 employees of LPU-Cavite. The result showed that 94.87% gave a strong support in having AR business cards, and 82.05% agreed that traditional business cards need modernization through AR technology. 97.43% believed that professional networking can be enhanced using AR, and 94.87% said that using AR business cards can help LPU-Cavite be presented as a technologically advanced institution.

To address the issues mentioned and the needs identified in the survey, the research aims to combine AR and traditional business cards to dynamically updated information and enhance engagement and interaction in networking. The project will utilize the Kalman Filter algorithm to enhance AR tracking accuracy and stability by reducing jitters, thereby improving the overall AR experience [5], [6].

# Related work

## Business Cards in Modern Marketing

Business Cards are critical in professional branding, contributing to the image and identity for individuals and businesses [7].

## Limitations of Traditional Business Cards

Traditional business cards are often limited due to their static content. After it is printed, its contents, such as name, address, and contact information it contains cannot be updated dynamically. This serves as a problem for people and businesses that frequently change their contact information. Updating the business card would be costly and require re-prints, which can be time-consuming because its static nature would diminish the usefulness of business cards in a constantly changing industry [4]

## Augmented reality Technology as a Digital Solution to marketing

Augmented Reality (AR) improves upon traditional business networking approaches and techniques, overlaying interactive digital overlays onto physical, likely remembering the last encounter with someone for your business. AR lets the traditional business card, similar to the object, be a dynamic and much more immersive experience vis-à-vis print. While printed cards typically include no more than Council language and a few sentences, an AR business card can deploy professional demo video link(s), social media link(s) and incorporate updates (distinguishing current details against an obsolete card). By adapting Augmented Reality, you are reducing waste but also handing the recipient a current overview of current info [7]. AR not only immersively and engagingly connects every professional but also indicates a type of forward-thinking process which can illuminate trust as the associate is more likely to remember the encounter through the AR card. Or in a word, geomantic way, geography is planned and executed by man. Almost every professional and/or professional realm is filled with competition in the year 2023. Adapting something new or innovative such as AR and showing an individual is technology fluent can go quite a long way.

## Challenges in Marker Detection for AR Applications

Detection of markers is an important part of any Augmented Reality (AR) system, as they provide the points of reference to correctly position virtual content in a physical space. The accuracy of marker tracking is directly related to the placement and stability of AR objects, enabling the user to have a seamless and user-friendly experience [9]. Low available light is a significant challenge for marker detection. Low light availability on the marker will reduce the detection of features and edges to identify the marker [8]. If the contrast between the marker and the background is low it can result in a delayed recognition or no recognition of the marker, once again detracting from the user experience [8]. An additional challenge in AR business card applications is the small size of markers, as the fewer visible features and edges will reduce the likelihood of detection especially at a distance or from angle. Due to edge occlusion of the marker during this time decreases the detection accuracy [10]. These limitations are generally mitigated using enhanced image processing functions and adaptive algorithms that will recognize the marker across a wide variety of environments.

## Kalman Filter Algorithm in Augmented Reality

The Kalman Filter (KF) algorithm is a popular alternative to enhance augmented reality (AR) marker tracking (reduce noise) and to take as much noise out of the data of the marker tracking, as possible, to produce an accurate and stable virtual-real fusion. The KF algorithm works in a repeated predict-update process to estimate the states of an object (position, velocity etc.) over time with regards to occlusion and sensor noise. It is low computationally, making it an appropriate algorithm to use in real-time application of AR, where speed and accuracy is important. In a recent article by Scaler Topics [11], it suggests that the KF will provide the best estimates when dealing with linear Gaussian systems, and its extensibility allows it to adapt to different tracking models, with complex motion, as well as being able to keep up to date in non-linear systems with noise.

# Methodology

The development process was guided by a conceptual framework based on the input-process-output (IPO) model, implemented using Agile methodology. System evaluation was conducted using recognized software quality standards and user-centered assessment tools.

## Research Framework

This study adopted an iterative system development approach guided by an input-process-output (IPO) conceptual framework. Agile methodology was used to develop the system in short sprints, with continuous stakeholder collaboration and refinement. Evaluation of the system followed the ISO/IEC 25010 software quality standard and MARS usability metrics.

## System Overview

The system is composed of two major components: the PartnAR mobile application, and a Content Management System (CMS). The PartnAR application enables business card recipients to scan the physical business cards, retrieve user contents, and display interactive AR content. PartnAR utilizes Kalman Filter algorithm for optimized tracking of the AR elements to the physical business cards. The CMS allows business card owners and administrators to manage user profiles and content. A centralized database connects both systems, ensuring real-time access to updated information.

## Development Approach

The system was developed using the Agile methodology, conducting 2–3-week sprints with continuous integration and regular sprint reviews. The AR mobile application was developed using Unity and Vuforia, with programming handled in C#. The CMS was built using HTML, CSS, and JavaScript for the frontend and Node.js with Express.js for the backend. Backend communication was supported by a centralized database.

## Participants and Setting

The system was deployed and tested at Lyceum of the Philippines University – Cavite. A total of 86 participants were involved in evaluating the system. These included 30 faculty members, 20 academic support personnel, 10 senior leaders, 10 IT experts, 12 external HR personnel, 2 content administrators, and 2 management administrators. Each group contributed to specific aspects of the evaluation, such as technical performance, usability, administrative workflow, and content accuracy. Participants were selected through purposive sampling to ensure feedback from all relevant user groups.

## Evaluation Metrics

To evaluate the effectiveness of the algorithm in improving marker tracking, four performance metrics are analyzed across five tracking methods: Kalman Filter, Unscented Kalman Filter, Extended Kalman Filter, Cubature Kalman Filter, and using no algorithm.

1. Root Mean Square Error - Determines how filtered close filtered values are to the raw values. Lower RMSE implies more accuracy.

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1. Tracking Jitter - Measures the stability of the position of the business card between frames. Higher jitter value means higher unstable tracking.

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1. Detection Rate - Frame proportion in which the business card was successfully detected and tracked.

(3)

1. Processing Time per Frame - The average time it takes to process each frame. Lower processing time is preferable for real-time applications.

(4)

## Evaluation Method

System quality was evaluated using the ISO/IEC 25010 standard, focusing on characteristics such as functionality, performance efficiency, usability, reliability, maintainability, and portability. Additionally, usability and acceptance were assessed using the Mobile App Rating Scale (MARS). Stakeholders, including internal and external users, completed Likert-scale questionnaires and provided qualitative feedback. This dual evaluation approach ensured a comprehensive assessment of both technical performance and user experience. The questionnaire followed empirical validation guidelines and utilized Cronbach’s alpha for reliability testing [20].

# Results and discussion

The system is evaluated through different testing phases, including functionality and compatibility tests, ISO 25010 evaluation for the CMS, MARS for the PartnAR mobile application, and algorithmic comparison for different tracking methods.

## Functionality Test

1. Funtionality testing results

| **Respondents** | Pass | Fail | Test Criteria | Percentage |
| --- | --- | --- | --- | --- |
| Technical Adviser | 112 | 0 | 112 | 100% |
| Admin | 112 | 0 | 112 | 100% |
| IT Experts | 112 | 0 | 112 | 100% |

The functionality test was done by 3 types of respondents: technical adviser, system administrator, and IT experts; with each respondent 112 test cases were given to verify the overall performance of the system, including system responsiveness, tracking accuracy, data retrieval, and content presentation. The results showed that there were no failed test cases during the process, confirming that the system successfully met all functional requirements during the testing phase.

## Compatibility Test

1. COMPATIBILITY testing results

| **Respondents** | Pass | Fail | Test Criteria | Percentage |
| --- | --- | --- | --- | --- |
| Technical Adviser | 23 | 0 | 23 | 100% |
| Admin | 23 | 0 | 23 | 100% |
| IT Experts | 23 | 0 | 23 | 100% |

The compatibility test was also conducted by the technical adviser, administrator, and IT experts. Referring to Table 2, it can be observed that each of the respondents tested the system against 23 test cases, including performance across different Android versions, browser compatibility, and hardware requirements, The results suggest that the system is fully compatible with the target platforms, having a 100% pass rate overall.

## ISO/IEC 25010

1. Evaluation results of cms

| **Category** | Mean | SD | Verbal Interpretation |
| --- | --- | --- | --- |
| Functionality | 3.59 | 0.280 | **Strongly Agree** |
| Performance Efficiency | 3.44 | 0.332 | **Strongly Agree** |
| Compatibility | 3.58 | 0.361 | **Strongly Agree** |
| Usability | 3.48 | 0.327 | **Strongly Agree** |
| Reliability | 3.48 | 0.321 | **Strongly Agree** |
| Security | 3.51 | 0.339 | **Strongly Agree** |
| Maintainability | 3.55 | 0.32 | **Strongly Agree** |
| Portability | 3.52 | 0.325 | **Strongly Agree** |
| **Average** | **3.52** | **0.33** | **Strongly Agree** |

The CMS evaluation using ISO/IEC 25010 with a total of 74 respondents, including IT experts, administrators, faculty, and support staff. Using eight quality characteristics, the results showed consistent high ratings. The overall mean score was 3.52, showing strong user satisfaction. The highest rated characteristic was Functionality (3.59) while performance efficiency (3.44) achieved the lowest yet still highly rated, indicating potential changes for improvement. A low standard deviation of 0.33 suggests that the users gave consistent feedback.

## Mobile Application Rating Scale

1. Evaluation results of Partnar app

| **Category** | Mean | SD | Verbal Interpretation |
| --- | --- | --- | --- |
| Engagement | 3.59 | 0.322 | **Strongly Agree** |
| Functionality | 3.53 | 0.385 | **Strongly Agree** |
| Aesthetics | 3.62 | 0.373 | **Strongly Agree** |
| Information | 3.61 | 0.363 | **Strongly Agree** |
| **Average** | **3.59** | **0.36** | **Strongly Agree** |

The MARS evaluation for the mobile application assessed its engagement, functionality, aesthetics, and information quality. With 86 respondents, which included internal users and external HR personnel, the results show consistent high ratings across all categories, with an overall mean score of 3.59. The highest rated category was Aesthetics (3.62), while the lowest was functionality (3.53).

## Testing Results of Different Tracking Methods

1. tracking methods results

| **Method** | RMSE | Tracking Jitter | Detection Rate | Processing Time per Frame (s) |
| --- | --- | --- | --- | --- |
| No Algorithm | 0 | 0.37 | 60.99% | 0.000087 |
| KF | 0.05 | 0.07 | 88.56% | 0.000134 |
| UKF | 0.16 | 0.86 | 90.69% | 0.000139 |
| EKF | 0.01 | 0.93 | 89.46% | 0.006299 |
| CKF | 0.79 | 0.12 | 96.17% | 0.000144 |

The study used five tracking methods: Using no algorithm (the baseline), Kalman Filter, Unscented Kalman Filter, Extended Kalman Filter, and Cubature Kalman Filter. These were evaluated through its RMSE, tracking jitter, detection rate, and processing time per frame. The baseline showed poor detection and instability in tracking, the EKF had the lowest RMSE (0.01), indicating high tracking accuracy, but suffered from high jitter and slow processing. UKF and CKF both have high detection rates but also showed high tracking jitter and tracking error. Standard KF performed with the most balanced results, achieving a low RMSE (0.05), reduced jitters (0.07), and fast processing, making it ideal for real-time applications.

## PartnAR Descriptive Analysis

A final evaluation was conducted among 6 respondent groups. The A final evaluation was conducted among 6 respondent groups in order to assess the usability, innovation potential, professional value, and performance of the system. The content and HR administrators from LPU-Cavite gave the highest ratings, particularly the features and presentation of the system. The faculty members and external HR personnel supported the effectiveness of the system for enhancing professional connections and its innovative potential. And lastly, the senior leaders acknowledged its visual and professional impact to its recipients. Overall, the system was highly approved for its tracking stability and visual appeal, however, further improvements were recommended in compatibility and performance.

# Conclusion and future work

The study presented PartnAR, an AR-based business card system designed to create a more engaging and professional medium of interaction for LPU-Cavite employees to present information to potential clients, customers, and collaborators, with the use of Kalman Filter for enhancing tracking stability and overall AR camera performance. Users and administrators were able to dynamically update their business card details and university information by integrating a CMS in the system.

Across 139 test cases, the functionality and compatibility testing showed the stability and reliability of the system with a 100% pass rate. The CMS got a highly acceptable rating of 3.52 in the ISO/IEC 25010 evaluation, while the partnAR mobile app got an average score of 3.59. This suggests that the system demonstrated effective functionality, ease of use, and a positive user experience. The comparison between tracking methods suggest that KF performed the most optimal across all the metrics, which shows its reliability in a real-time application. The descriptive analysis also shows that the system shows a positive impact in establishing connections through AR.

The evaluation results demonstrate that the system meets all of its key quality attributes and successfully delivers the intended functionalities to its target users, maintaining consistent and optimal performance in all of its supported platforms and offers a user-friendly experience. The future work of the study will focus on expanding the mobile application compatibility to IOS, further improving detection and recognition accuracy for different text sizes, integrating cloud storage for efficient management and scalability, and allowing users to upload their own 3D models through the CMS.

##### Acknowledgment

The researchers would like to express their sincere gratitude to Mr. Vincent C. Cortiñas and Dir. Lourdes C. Reyes for their invaluable coordination with our study. Special thanks to the LPU faculty employees, administrators, IT experts, and external HR personnel who participated in the system testing and evaluation for their time, insights, and valuable input. Appreciation is also extended to Ms. Kristel Jane S. Bawag and Sheirlyn A. Abalain for their assistance throughout the research process. Finally, the research would like to thank Dr. Elmer C. Matel, their research adviser, by providing them with knowledge, support, and encouragement throughout the duration of the research.

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**Video Presentation:** <https://drive.google.com/file/d/1HQFiSM5jrH4a2fwAmrMsPaTcempQeWcp/view?usp=drive_link>