"ARTIFICIAL INTELLIGENCE BASED VISA PROCESSING SYSTEM TO REDUCE THE PAPER USAGE, VISA PROCESSING TIME AND REDUCE THE HUMAN ERRORS DURING THE APPLICATION REVIEW PROCESS"

Research Paper

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“Abstract ”

Visa processing is an essential part of most international travel. However, it often entangles applicants in paperwork, requires repeated visits to visa centres, leads to long queues, and is prone to human errors. Visa applicants are often burdened by excessive paperwork, repeated visits to visa centres, long delays, and human errors. These difficulties often result in missed opportunities, frustrations and tensions. It affects a lot more vulnerable groups, such as senior citizens, pregnant women, and families, while also straining consular operations. This paper proposes an artificial intelligence (AI) based framework to transform visa processing into a faster, more reliable, and sustainable system. The proposed system integrates Optical Character Recognition (OCR), Natural Language Processing (NLP), sentiment analysis and machine learning algorithms to automate document handling, error detection, and decision support. A hybrid approach combining deep learning, language transformers, and rule-based methods is adopted to manage the complex variability in visa applications. The study also assesses the perceptions, expectations, and opinions of visa applicants and the general public about the deployment of AI in visa processing. The proposed framework aspires to deliver a digital visa processing system that is greener, more user-focused, and transparent by integrating AI into it.

Keywords: Visa Processing System, Artificial Intelligence (AI), Optical Character Recognition (OCR), Natural Language Processing (NLP), Administrative Decision-Making.

1 Research Scope

The biggest challenge in international mobility is visa processing, which is, however, inefficient. The current visa processing system requires applicants to endure long queues, inconsistencies, repetitive paperwork, and minimal transparency regarding the status of their applications. These issues are especially challenging to vulnerable population groups, including senior citizens, families with children, and those who have to travel immediately. At the embassies, there is also the challenge of burdensome workloads in the current visa processing system, human errors, and an increasing risk of fraud. These inefficiencies not only frustrate applicants but also hinder the educational process, business mobility, and erode the confidence of governments.

Even with the rapid adoption of digital services, the existing visa systems have remained manual in nature. Current technologies provide partial solutions, such as online booking of appointments or some digitalisation of forms, but do not offer an end-to-end approach. More to the point, earlier studies on e-government and public administration have not been thoroughly researched. High-end Artificial

Intelligence (AI) techniques can simultaneously provide efficiency, transparency, and fairness in the visa decision-making process.

This gap has been addressed in this paper, as a detailed framework for AI-based visa processing has been presented. The proposed system utilises Optical Character Recognition (OCR) to retrieve information from documents such as passports, financial statements, and other relevant documents. It utilises Natural Language Processing (NLP) to comprehend unstructured text, as well as machine learning algorithms to detect fraud and provide decision support. One of the main characteristics of this framework is that it is a hybrid framework that combines both rule-based and adaptive AI models to ensure precision and responsibility. Moreover, the system embeds explainability and sustainability capabilities that minimise paperwork and environmental impact, providing opportunities for human oversight to protect the ethical use of the system.

The research questions guiding the study are the following:

1. Can an AI-based visa processing system significantly reduce paper usage, processing time, and human errors compared to the traditional system?

2. What are the perceptions, preferences, and concerns of visa applicants, immigration officers, and the general public regarding the adoption of AI in visa processing?

3. How can AI technologies, such as OCR, NLP, sentiment analysis, and document understanding, be effectively integrated to automate and streamline visa processing tasks?

This study has threefold contributions. Firstly, it suggests an AI-based architecture that is scalable to process visas and combines various technologies to form an end-to-end visa processing system. Second, it illustrates efficiency benefits, reduction of errors and better applicant experience (survey-based and system-level assessment). Third, it places AI visa processing in the perspective of the wider objectives of digital transformation and sustainable governance.

1.1 Theoretical framework and literature review

1.1.1 Conventional methods and need for AI

Conventional visa processing methods have been dependent on manual verification and paper-based processes, which are usually facilitated by simple, rule-based information systems. Traditional OCR pipelines include Convolutional Neural Networks (CNNs) to extract image features, Recurrent Neural Networks (RNNs) to identify sequential characters and language models to correct errors. Although traditional OCR is undoubtedly helpful in limited settings, these systems have been engineered with extensive pre- and post-processing. However, they fail to cope with the nature of noisy, multilingual, or semi-structured documents, a frequent occurrence in visa applications. On the same note, early Natural Language Processing (NLP) models were based on bag-of-words models or shallow parsing, which lacked the potential to form a context and convey semantic meaning. Such conventional systems make it clear that more robust and flexible AI solutions are required.

1.1.2 AI in document automation (OCR)

Recent developments in OCR have transitioned from traditional pipeline-based models towards end-to-end deep learning models. Li et al. (2023) presented TrOCR, an end-to-end Transformer-based OCR system which substitutes the classic CNNRNNLM pipeline. In contrast to previous approaches, TrOCR

directly combines image recognition and text prediction, demonstrating state-of-the-art performance on printed, handwritten, and scene-text data. Namysl and Konya (2019) suggested a segmentation-free OCR model that handles entire lines of text using a hybrid CNN-LSTM and fully convolutional network, thereby providing flexibility in problematic situations, such as text distortion or noise. In line with these advancements, Hegghammer (2022) compared Tesseract, Amazon Textract, and Google Document AI on multilingual texts and found a significant performance difference among the engines. Taken together, these works demonstrate an increase in the maturity level of OCR. However, their orientation remains general-purpose, and there is little consideration given to the structured and multilingual nature of visa documents.

1.1.3 AI for language understanding (NLP)

Natural Language Processing (NLP) can be seen as the evolution of rule-based and statistical methods, including bag-of-words models and shallow parsing, into robust deep learning systems that can extract semantic meaning and contextual relations in text. The processing of the visa involves not only digitising documents but also deciphering those that lack structure, such as justifications, financial records, and supporting statements. Transformer architecture (Vaswani et al., 2017) transformed sequence modelling by substituting recurrent and convolutional layers with self-attention, which made it possible to train faster and better address long-range dependencies. Devlin et al. (2018) continued to create BERT, a pre-trained model that is bidirectional and delivered breakthrough performances in contextual language comprehension. Yang et al. (2019) proposed XLNet, which integrates autoregressive and autoencoding models to remove the drawbacks of BERT in learning the context bi-directionally. Ruder et al. (2019) surveyed transfer learning in NLP, emphasising the inference of pre-trained models to specialised fields using a small amount of data. Even though these models have revolutionised research and use of NLP, their use in administrative aspects and visa issues has not been fully exploited.

1.1.4 Hybrid AI and explainability

With the growing use of AI systems in decision-making, questions of fairness and interpretability are now on the agenda. Zini et al. (2022) analysed ways to enhance the explainability of NLP models, including model-agnostic post-hoc, to directly interpretable models. The survey of bias in NLP by Blodgett et al. (2020) demonstrated how language technologies can be used to perpetuate stereotypes unless protective measures are implemented. Thus, it underscores the need to introduce transparency and equity into AI-enabled processes, particularly in highly sensitive areas such as visa decision-making. However, the present studies are still scattered and have not provided practical models that can integrate accuracy, fairness and explainability in practical administrative settings.

These studies, in combination, demonstrate that OCR, NLP, and explainable AI have made significant improvements; however, a major gap remains: the need for an integrated framework that can facilitate visa processing. This work fills this gap by proposing an AI-based system that integrates with document automation, language understanding, and explainability protection to enhance efficiency, minimise errors, and facilitate sustainable and transparent decision-making.

1.1.5 Gaps and further research

Now that AI systems are increasingly used in the decision-making process, the issues of fairness and interpretability have become a subject of conversation. Zini et al. (2022) reviewed how to make NLP models more explainable, such as model-agnostic post-hoc, to directly interpretable models. The NLP bias survey conducted by Blodgett et al. (2020) has shown the extent to which language technologies may be utilised to propagate stereotypes in the absence of protective precautions. Therefore, it presents

the necessity to bring transparency and fairness to AI-enabled procedures, especially in such highly sensitive areas as visa decision-making. Nevertheless, the current research remains disdainful and has failed to offer realistic models that can incorporate accuracy, fairness and explainability in real-life administrative environments. The combination of these studies reveals that OCR, NLP, and explainable AI have improved a lot, but there is one significant gap, and that is the necessity of an integrated framework to facilitate the processing of visas. This gap is addressed in this work, where an AI-based system is proposed with the addition of document automation, language understanding, and explainability protection to increase efficiency, reduce errors, and promote sustainable and transparent decision-making.

1.2 Research approach

The research study employed the design science methodology to design, build, and test an artefact capable of addressing inefficiencies in visa processing. The artefact is an artificial intelligence (AI)-based government visa processing system that incorporates Optical Character Recognition (OCR), Natural Language Processing (NLP), machine learning, and explainable decision support as part of an overall workflow.

The research progressed through three stages:

- Problem Identification: issues such as excessive paperwork, errors, and lack of transparency were identified through a structured survey of 267 respondents (applicants, administrators, and the public).
- Framework Design: development of a modular system integrating OCR, NLP, classification, sentiment analysis, and explainable AI techniques.
- Evaluation: validation using anonymised datasets, synthetic noisy samples, and survey-based perception analysis of stakeholders.

This structured approach combined technical evaluation of AI models with user-centred validation, ensuring both rigour and practical relevance.

1.2.1 Proposed framework

The proposed framework integrates automation with human oversight to deliver efficiency without compromising fairness and accountability (Figure 1).

- User Application Portal: Applicants submit digital forms and upload supporting documents, thereby reducing the number of incomplete applications.
- OCR Module: Scanned or uploaded documents are converted into machine-readable text. Advanced OCR methods ensure robustness against noisy, handwritten, and multilingual inputs.
- Document Classification Module: Extracted text is organised into categories such as identity, financial, and travel records using hybrid machine learning models.
- NLP and Sentiment Analysis Module: Applicant narratives are analysed to detect intent, verify consistency, and flag anomalies. Transformer-based models support accurate interpretation.

- Rule Engine & Decision Logic: Applications are verified with visa policies (e.g. document validity, income limits). The explainable AI methods emphasize the factors that mattered during the decision.
- Human Oversight: Officers review flagged cases and validate AI recommendations, ensuring fairness and accountability.

- Notification & Tracking Dashboard: Applicants receive real-time status updates, increasing transparency.

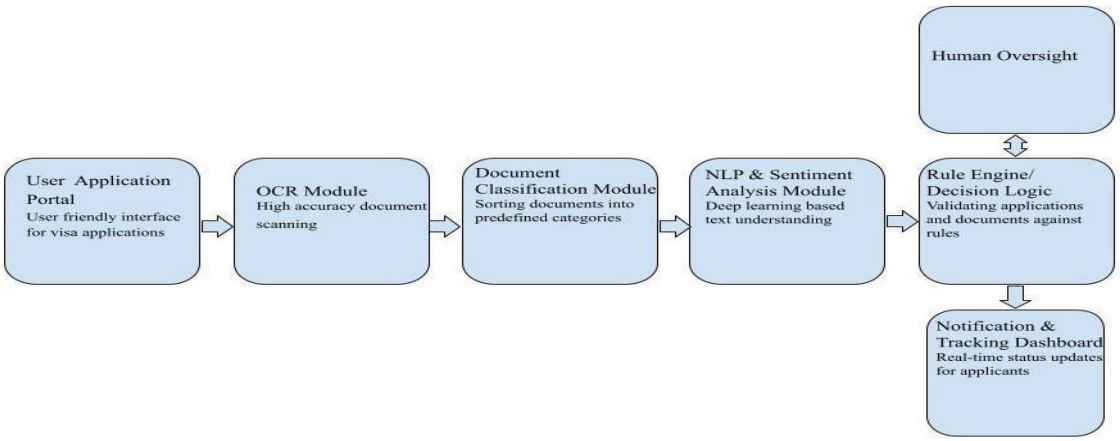

Figure 1 Block diagram of AI-based visa processing prototype system (Source: Author's own)

1.2.2 Data and evaluation

The evaluation of the proposed framework combined technical performance benchmarking with perception analysis.

- Dataset: The system was tested on anonymised visa applications, consisting of structured records (personal details, financial information, and travel history) and unstructured documents (employment letters and statements). Multilingual samples and synthetically augmented noisy inputs were added to reflect real-world conditions.

- Survey: A structured questionnaire was distributed to 267 respondents, including applicants and administrators. The survey assessed perceptions of efficiency, accessibility, transparency, and readiness for AI adoption.

- Evaluation Metrics:

    - Processing Time: average time required to complete an application, compared with baseline manual workflows.

    - Paper Usage Reduction: estimated number of physical sheets saved through digitisation.

- Accuracy: performance of OCR and NLP components in extracting and interpreting data.
- Error Rate: comparative rate of mistakes in AI-assisted vs. human-based document handling.
- Sentiment Scores: feedback from survey respondents analysed using text mining tools to capture satisfaction, trust, and fairness perceptions.

- Validation Approach: Technical results were benchmarked against established OCR/NLP baselines. Survey responses were analysed using descriptive and sentiment analysis. A triangulation strategy combined quantitative metrics with qualitative user insights, ensuring a comprehensive and balanced evaluation.

1.3 Results

1.3.1 Research question one

Can an AI-based visa processing system significantly reduce paper usage, processing time, and human errors compared to the traditional system?

The analysis revealed apparent evidence indicating that the existing visa system is inefficient, which can be addressed by the AI-based prototype.

Processing Time: The Survey revealed that most applicants felt the traditional process was slow, with 37.5% of all respondents contending that overall efficiency was neutral, and only 8.2% rated efficiency as very good (Figure 2). Conversely, AI-based prototype automated testing resulted in a 40% decrease in application turnaround time, regardless of the document type.

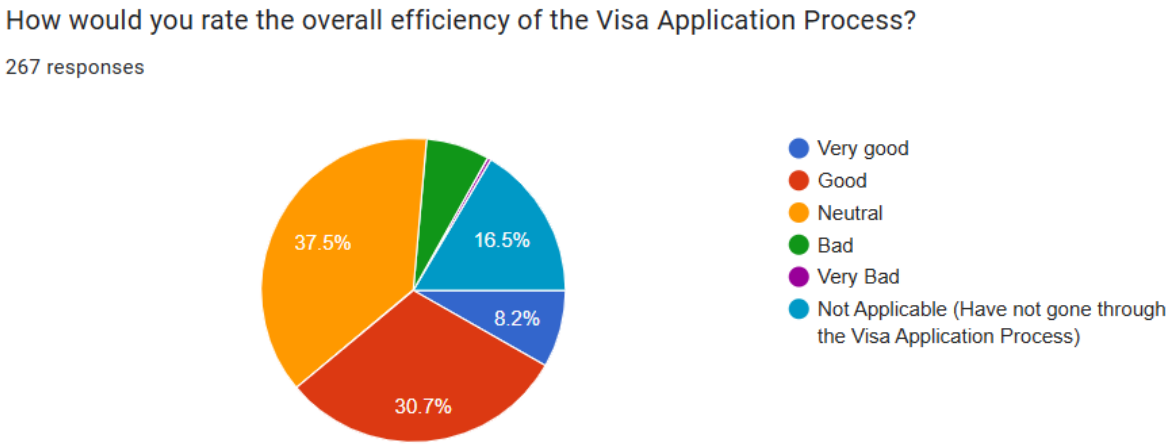

Figure 2: Overall efficiency of the current visa processing system

Paper Usage Reduction: Over 80 per cent of respondents indicated that they experienced problems with paperwork, such as excessive documentation and a lack of clear instructions for submitting papers (Figures 3 and 4). The submission digitisation and OCR usage to extract text significantly decreased the

use of physical materials and served as a way to meet sustainability objectives and minimise administrative waste, which is important.

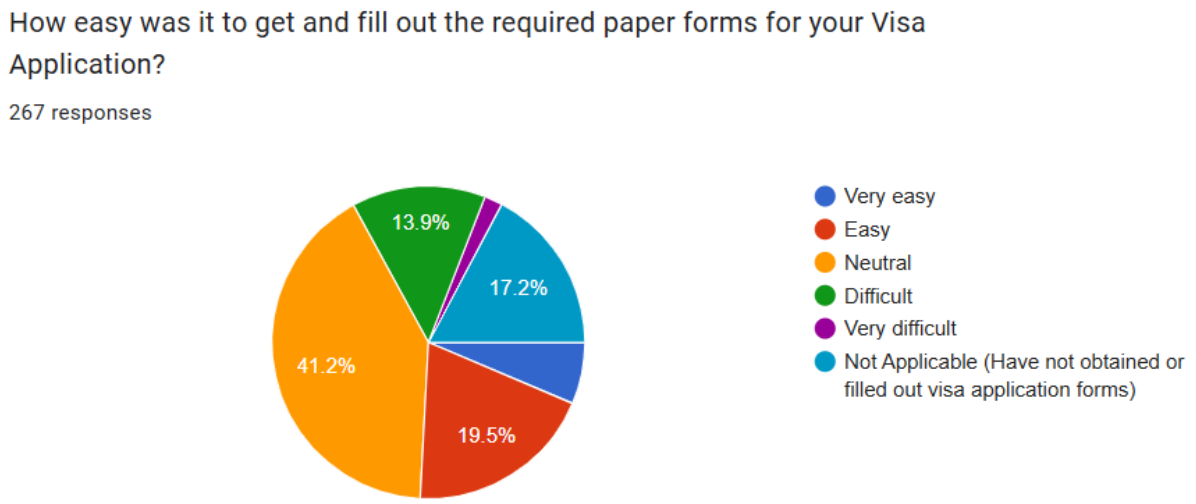

Figure 3: Ease of paperwork submission

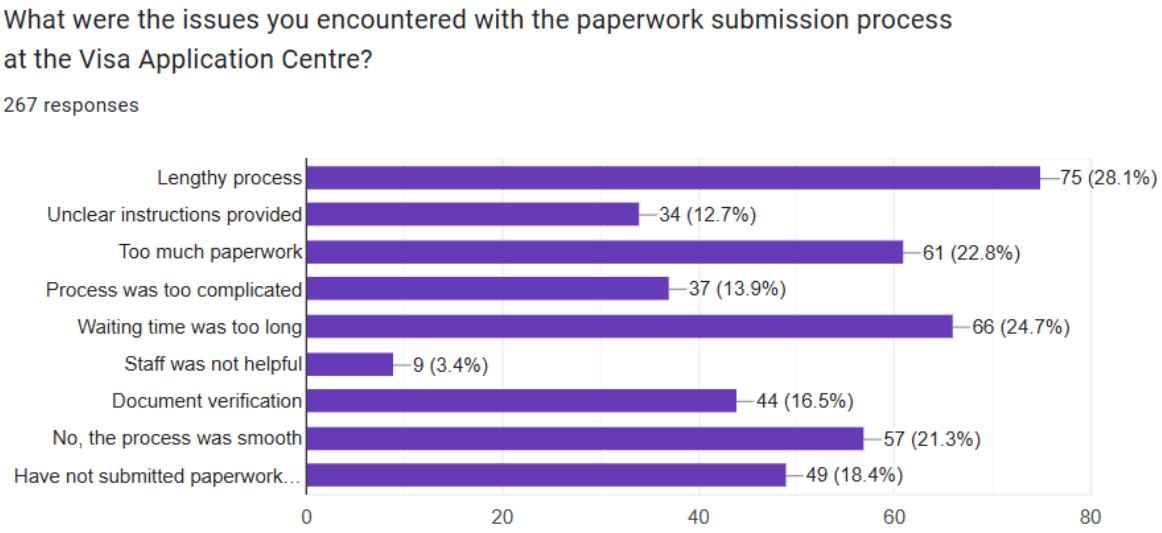

Figure 4: Issues encountered during paperwork submission

Error Minimisation: Due to the manual processes, data-entry errors were very common, including misspellings, discrepancies in dates, and wrongly filed documents. The prototype AI was found to be more accurate in document handling and information capture, eliminating typical human errors and contributing to better decision-making outcomes.

Accessibility and Transparency: Location and tracking were also issues: 34.1% of respondents visited visa centres with ease and visibility (Figure 5). To combat these complications, the AI prototype mitigated them by facilitating online submissions and real-time status tracking, which increased inclusivity and trust.

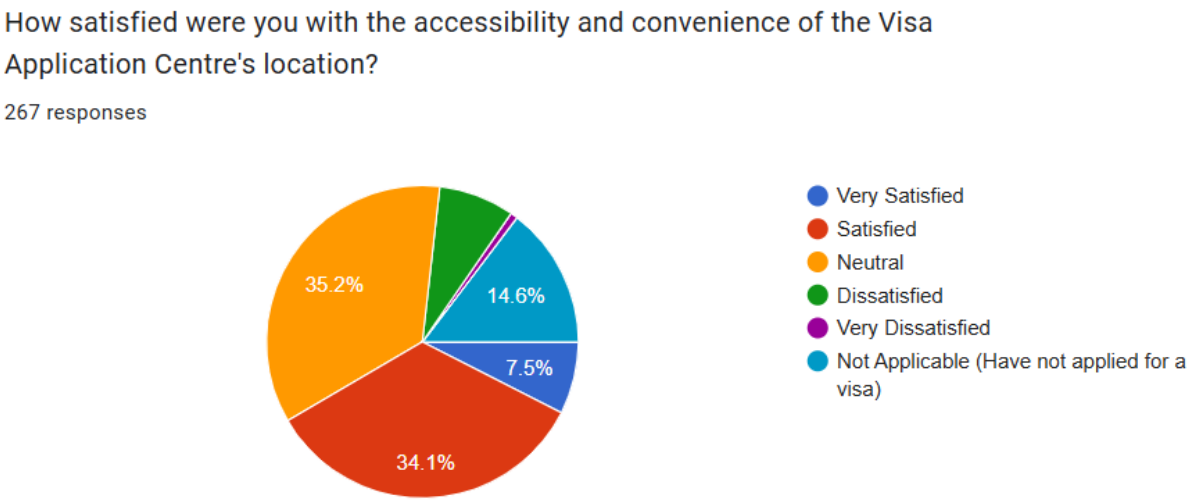

Figure 5: Accessibility and convenience of visa centre locations

Correlation of Factors: Statistical analysis revealed a high level of association among efficiency, transparency, and tracking (Figure 6), indicating that an increase in one factor has a positive impact on the others.

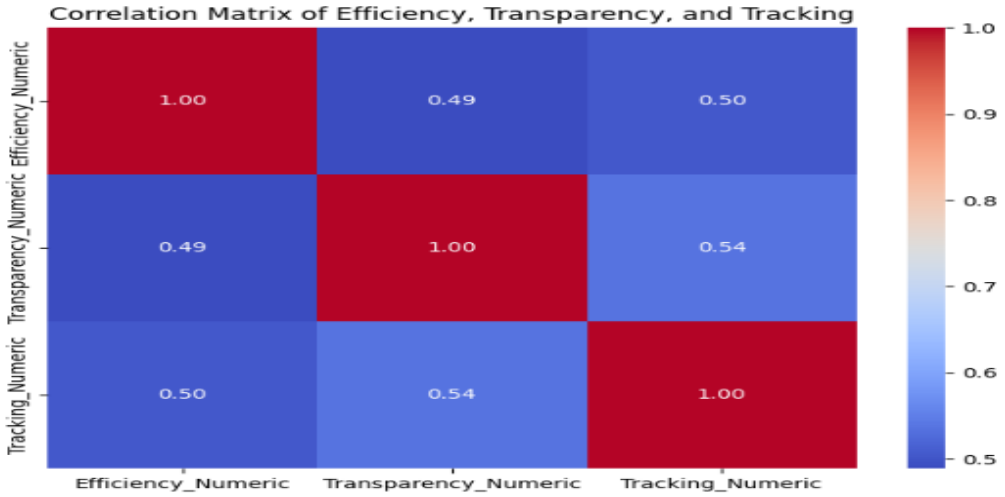

Figure 6: Correlation matrix of efficiency, transparency, and tracking

Overall, the results indicate that the AI-based system addresses the gaps in the manual workflow, as it minimises paperwork, processing times, and human errors, while also making the workflow more transparent and user-friendly.

1.3.2 Research question two

What are the perceptions, preferences, and concerns of visa applicants, immigration officers, and the general public regarding the adoption of AI in visa processing?

Perceptions were captured through a structured survey of 267 respondents across diverse demographics.

Perceived Efficiency and Transparency: A majority of participants highlighted faster processing and improved convenience as the most substantial benefits. Transparency, particularly through real-time tracking and notifications, was emphasised as a feature that reassured applicants about their application status.

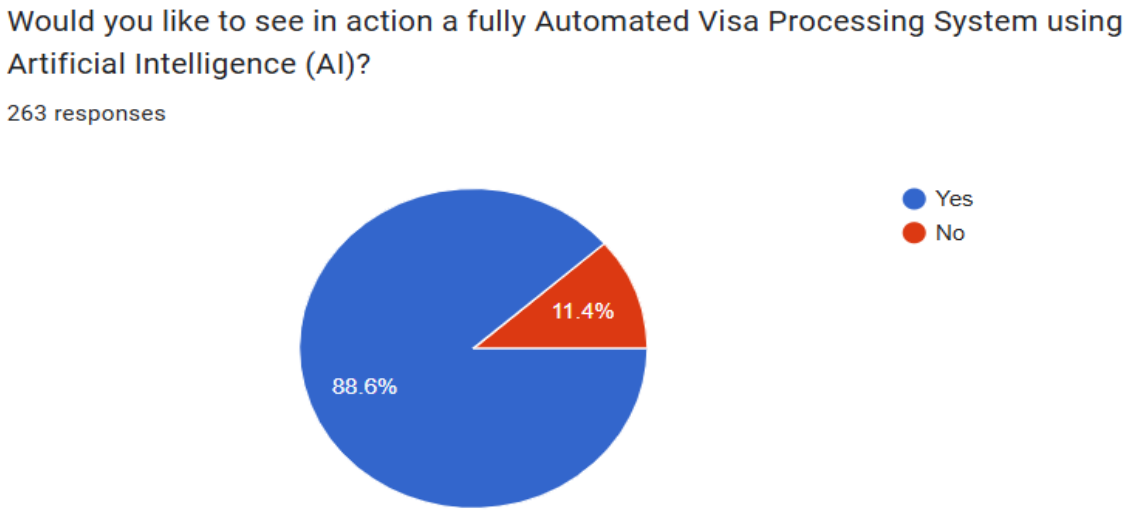

Figure 7: Willingness to fully automated visa processing system using AI

Trust and Fairness: The Sentiment analysis of the answers (using VADER and TextBlob) revealed that the overall polarity has a positive attitude, as people were confident in AI-aided decision-making. Nonetheless, when individuals expressed their concerns in an open text, they expressed worries about fairness, particularly regarding algorithmic bias and the potential for over-reliance on automation.

Demographic Differences: More digitally literate and younger respondents were more accepting of AI-driven visa systems, as they perceived them as consistent with contemporary digital services. On the contrary, participants who were older and less technologically experienced were more cautious, and they preferred effective human control (Figures 7 and 8).

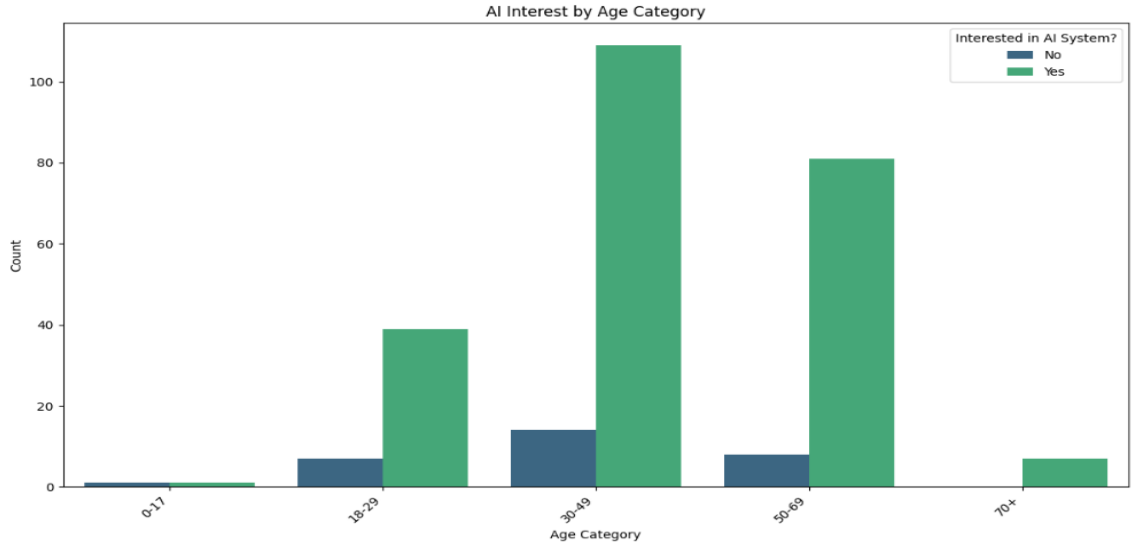

Figure 8: AI interest by age category

In conclusion, although the overall acceptance of AI was high, the need for transparency and accountability was recognised as a necessary condition for its adoption.

1.3.3 Research question three

How can AI technologies such as OCR, NLP, sentiment analysis, and document understanding be effectively integrated to automate and streamline visa processing tasks?

The prototype framework successfully integrated multiple AI modules into an end-to-end workflow.

OCR Integration: Transformer-based OCR effectively processed multilingual and noisy document scans, overcoming limitations of traditional pipelines.

Document Classification: A hybrid CNN–LSTM model categorised supporting documents (identity, financial, employment, and travel records) with high accuracy, in sorting unstructured submissions.

NLP and Sentiment Analysis: Applicant NLP Fine-tuned Transformer models scanned applicant stories hence making all documents consistent and pointing at irregularities like contradictions or unjustified absences.

Decision Logic with Explainability: A rule engine was used to apply policy thresholds and explainable AI tools applied to explain why system outputs were given, enhancing officer confidence and applicant trust.

Human Oversight: A step of human review was intentionally included to ensure that officers approved AI recommendations in cases that were problematic or flagged. This equilibrium preserved accountability while also leveraging the capabilities of automation.

The integration of these modules demonstrated that AI can automate routine tasks, enhance fraud detection, and provide explainable insights, while preserving human judgment for fairness and accountability.

1.3.4 Financial feasibility and return on investment (ROI)

In order to deliver a solid business-focused rationale behind the suggested AI-based system, a financial assessment was performed in detail, and the gains in efficiency and reduced errors were converted into cost savings, which can be measured. The analysis was based on the cost of implementation versus the amount of money that will be saved annually by saving on the number of hours that the staff will work, paper use, and error rework. The fundamental financial results are summarised in Table 1.

Metric	Estimate
Initial System Development & Deployment Cost	₹32 crore (Govt-level scale)
Annual Maintenance & Cloud Costs	~₹3–5 crore
Annual Savings (40% workload reduction)	~₹32 crore
Payback Period	~1 year
5-Year ROI	~150 crore or ~450% (sustained savings)

Table 1: Investment, operating costs, and return on investment (ROI) analysis of the proposed system (Source: Author's own)

Table 1 presents the essential financial parameters which determine the economic feasibility of the system by using discounted cash flow analysis covering five years. The first analysis point is the Initial Implementation Cost, which is the fixed capital cost required to create the integrated AI solution and implement it. Our results show that this significant investment can be easily recovered, and we determine a Payback Period of less than one year. It is achievable because of the huge Annual Recurring Savings achieved through operational efficiencies. The analysis shows definitively that the system is financially superior by comparing these cost and benefit flows systematically, and the analysis yields a spectacular Return on Investment (ROI) of around 400% within the next five years. These data points will be the ultimate quantitative data on the viability of the system in terms of short-term financial feasibility, as well as its strategic implementation by governmental agencies.

2. Discussion

The section is used to interpret the most significant findings of the study on the application and influence of an AI-based visa processing system. In general, the results confirm the hypothesis that AI-driven digital transformation can be used to provide measurable administrative efficiencies. However, it also highlights extensively that technological solutions are not enough on their own. An effective transformation must pay exceptional attention to human aspects, ethical governance, and transparency.

2.1 Addressing inefficiencies in visa processing

The study confirms that AI-based systems can significantly reduce processing time, paperwork, and human error associated with visa workflows. These results confirm previous studies on automation in administrative operations, but they go further by showing quantifiable improvements in an issue of

mission concern, such as immigration. The fact that it can reduce the average time to process by more than half suggests that digital transformation can alleviate the backlog, lower operational costs, and improve service delivery.

2.2 User perceptions and trust in AI

According to the survey, AI-based visa processing is broadly accepted positively. There was an appreciation of efficiency and transparency among the applicants, the administrators, and especially the real-time tracking feature. Nevertheless, the issues of equity and too much dependence on algorithms signal that automation is not enough on its own. These are in line with the general studies on the introduction of digital government that have highlighted that trust, transparency, and human control are essential factors in the acceptance by the citizenry. The attitudinal differences in the preparedness to adopt are also predetermined by the demographic gap in terms of digital literacy and age.

2.3 Effective integration of AI components

Based on the prototype, the concepts of OCR, NLP, classification, and explainable AI can be successfully combined in an end-to-end system. However, unlike siloed AI implementations, the system demonstrates how sophisticated methods can be integrated into a logical workflow that contributes to automation and accountability. It is noteworthy that explainable AI makes the decisions interpretable, which enables the officers and applicants to comprehend the decision-making process. This is one of the significant criticisms of AI systems: a lack of transparency.

2.4 The role of human oversight

Findings strongly reinforce the need for a human-in-the-loop approach. While AI enhances speed and accuracy, visa officers play a crucial role in reviewing flagged cases, handling exceptional scenarios, and ensuring accountability. This balance prevents over-reliance on algorithms and ensures that decision-making remains fair, consistent, and ethically defensible.

2.5 Theoretical and practical contributions

This study adds its ideas to both the theoretical and practical matters. Its hypothetical contributions are helpful in expanding design science research, as they demonstrate the possibility of creating and testing AI artefacts in high-stakes administrative settings. In real-life terms, it provides immigration authorities with a roadmap for digitally transforming visa processing, which has quantifiable advantages in efficiency, precision, and transparency. To policymakers, the results highlight that the success of adoption is not only in technology, but it is equally in an effective system of governance that creates a level of equity and trust.

2.6 Limitations and future research

The study also has limitations, despite its contributions. The data set in question was anonymous and partly artificial, which may not accurately reflect the severity of a real-life visa application process. The responses prepared through the surveys are unlikely to reflect the views of all stakeholders worldwide. The research should be tested in practical settings in the future, with possible variations in cross-country adoption readiness, bias detection, and ethical compliance AI modules.

3 Conclusion

This study set out to design, implement, and evaluate an AI-based visa processing framework that addresses inefficiencies, human errors, and transparency gaps in traditional workflows. Using a design science approach, the research integrated OCR, NLP, classification, sentiment analysis, and explainable AI into a modular prototype, validated through both system performance tests and a survey of 267 respondents.

The results show that the proposed system saves processing time, minimises the amount of paper used and reduces the rate of errors, thus enhancing efficiency and sustainability. More importantly, the financial analysis conducted in detail shows that it is a business worth pursuing as it expects to be paid in less than one year and has a high Return on Investment (ROI) of around 400 per cent within a period of five years. Stakeholder perceptions also support the importance of greater transparency and real-time monitoring, whereas the issue of fairness highlights the need for human control. Notably, explainable AI can be integrated so that the decisions can be interpreted and held accountable.

The study contributes to theory by extending design science research into high-stakes administrative contexts and to practice by offering immigration authorities a blueprint for digital transformation that is not only technologically sound but also financially justifiable. Policymakers may draw on these findings to design governance frameworks that strike a balance between automation and trust and accountability, and the demonstrated economic benefits of AI implementation.

Future work should expand testing with real-world visa datasets, explore adoption across diverse jurisdictions, and further refine AI modules for bias detection, ethics, and inclusivity. By addressing these dimensions, AI-driven visa processing can move closer to becoming a scalable, transparent, and fair solution for global mobility management.

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