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Study of Physical and Printing Characteristics of Pan Card and Their Forensic Significance

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Abstract

The present study is based on the characteristics (physical and printing) of PAN card to evaluate their forensic significance in document authentication. A total of 30 original PAN card samples were collected and they were examined using hand lens, stereomicroscope, ultraviolet illumination and dimensional measurements. Features such as printing characteristics, ink distribution, layout consistency, fluorescence behavior, and holographic features were analysed and compared across all samples. The results revealed a high degree of uniformity in the dimensions, layout design, the placement of textual information, photograph, signature panel and homogenous luminescent responses. In conclusion, original PAN cards possess distinctive and reproducible physical, printing, UV and holographic characteristics which can assist in document authentication and forgery detection.

Keywords- PAN (Permanent Account Number), Hologram, Microtext, Forgery

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I. INTRODUCTION

Identity documents play a vital role in modern society by establishing an individual's identity and facilitating access to various financial, legal, and administrative services. Among the different identity documents used in India, the Permanent Account Number (PAN) card is one of the most important and widely accepted forms of identification. Issued by the Income Tax Department of India under the Income Tax Act, 1961, the PAN card provides a unique ten-character alphanumeric identifier that enables the tracking of financial transactions and ensures compliance with taxation regulations (Hanchate *et al.,* 2023). Over the years, the use of PAN cards has expanded significantly, making them essential for activities such as filing income tax returns, opening bank accounts, purchasing property, and conducting high-value financial transactions. The growing dependence on PAN cards in both public and private sectors has also increased the risk of document-related crimes, including forgery, counterfeiting, identity theft, and unauthorized alterations (Mohanapriya *et al.*, 2025). Fraudulent PAN cards are often used in financial scams, tax evasion, money laundering, and other criminal activities. As printing and digital editing technologies continue to advance, counterfeit documents have become increasingly sophisticated and may closely resemble genuine documents. Consequently, the authentication of PAN cards has become an important concern for law enforcement agencies, financial institutions, and forensic experts (Hamza *et al.*, 2026). Forensic document examination provides scientific methods for assessing the authenticity of questioned documents. The examination of a PAN card involves the analysis of its physical characteristics, printing features, security elements, and overall document construction. Genuine PAN cards are produced according to standardized specifications and therefore exhibit consistency in dimensions, layout, printing quality, and security features. Any deviation from these established characteristics may indicate forgery or tampering (Sharma *et al.,* 2024).PAN cards incorporate multiple security features designed to prevent unauthorized reproduction and ensure document authenticity (Joshi *et al.,* 2024). These include holographic elements, ultraviolet-reactive features, secure printing techniques, microtext, and specialized background patterns. The effectiveness of these security features depends on their complexity and the difficulty involved in reproducing them accurately (Dhakal *et al.,* 2025). Careful examination of such features can provide valuable evidence regarding the genuineness of a document. The present study focuses on the systematic examination of the physical and printing characteristics of genuine PAN cards and evaluates their forensic significance. By establishing baseline characteristics and identifying consistent features present in authentic documents, the study aims to provide useful reference standards for forensic document examiners. The findings may contribute to the development of reliable and practical methods for PAN card authentication and support efforts to detect document fraud and identity-related crimes.

II. METHODOLOGY

This study was carried out to examine the physical and printing characteristics of genuine PAN cards and to assess their importance in forensic document examination. For this purpose, thirty PAN card samples were collected from individuals who voluntarily provided them for research. Care was taken to ensure that all samples were genuine and officially issued documents. Throughout the study, the cards were handled carefully to avoid any damage or alteration, and the confidentiality of personal information was maintained. The examination began with a detailed visual inspection of each PAN card. Features such as the overall appearance, dimensions, surface texture, colour scheme, layout design, photograph, signature panel, and printed information were carefully observed. The length and width of the cards were measured to determine whether they followed a consistent standard. A hand lens was then used to examine the printing quality in greater detail. Particular attention was given to the clarity of the text, font style, character spacing, alignment, and any visible defects such as smudging or irregular printing. To obtain a closer view of the printed features, the cards were further examined under a stereomicroscope. This helped in studying the distribution of toner, the sharpness of printed characters, and any indications of tampering, abrasion, overwriting, or other alterations that might not be visible to the naked eye. The PAN cards were also examined under ultraviolet (UV) light to observe fluorescent security features and hidden design elements. In addition, the holograms present on the cards were studied under different angles of illumination to evaluate their optical characteristics and microtext features. All observations were recorded systematically and compared across the examined samples. The collected information was then analyzed to identify common characteristics of genuine PAN cards and to establish reference features that could assist forensic experts in the authentication of questioned documents and the detection of forged or altered PAN cards.

III. RESULTS

a) Substrate and Surface Features

Physical examination of all PAN card samples revealed that the cards were manufactured using a laminated polymeric substrate possessing uniform physical characteristics. The substrate exhibited a smooth and homogeneous surface texture throughout the entire card area. No irregularities such as surface roughness, warping, cracks, scratches, peeling, or delamination were observed. The cards demonstrated moderate rigidity while retaining slight flexibility, which is consistent with the characteristics expected of secure identification cards designed for routine handling and prolonged use. Visual comparison among the samples did not reveal any noticeable differences in substrate quality, thickness, texture, or finish. The uniformity observed in the physical characteristics of the substrate suggests adherence to standardized manufacturing specifications and quality control measures during card production. Similar observations have been reported in forensic document examination literature, where uniform physical characteristics are considered important class features of genuine documents (Hilton, 1982; Huber & Headrick, 1999).

b) Dimensions and Layout

Measurement and comparative examination of the PAN card samples demonstrated a high degree of consistency in card dimensions and overall layout. All cards conformed to a standardized size, with only negligible variations that may be attributed to measurement tolerance rather than actual manufacturing differences. The placement of key information fields, including the cardholder's name, father's name, date of birth, PAN number, photograph, and signature panel, was found to be identical across all examined samples. The spatial arrangement of these elements exhibited precise alignment and proportional spacing, resulting in a balanced and organized layout. Margins surrounding the printed information were consistent, and no displacement, shifting, or misalignment of printed elements was observed. Such uniformity reflects the use of standardized digital templates and controlled printing procedures during card production (Ellen, 2006).

c) Background Design and Colour Pattern

Detailed visual examination of the background design revealed the presence of a uniform colour scheme and finely printed background patterns throughout all PAN card samples. The background elements appeared sharp, well-defined, and evenly distributed across the 14 Results card surface. No evidence of colour bleeding, fading, blotching, smearing, or uneven ink distribution was observed. The printed patterns retained their clarity and continuity throughout the examined areas, indicating high-quality printing. Furthermore, no defects such as banding, colour shifts, registration errors, or distortion of background motifs were detected. The consistency of colour tone and pattern distribution among all samples suggests a controlled and standardized printing process designed to maintain uniform appearance and security features.

d) Photograph and Signature Panel

Examination of the photograph area revealed that the cardholder's image was digitally printed directly onto the card surface and integrated seamlessly with the surrounding printed elements. The photographs exhibited clear image quality, proper contrast, and well-defined boundaries without evidence of physical attachment or replacement. No visible signs of pasting, cutting, lifting, tampering, or reattachment were observed. The transition between the photograph and adjacent printed areas appeared smooth and uninterrupted, indicating secure incorporation during card personalization. The signature panel was clearly demarcated and uniformly positioned across all examined samples. The printed boundaries of the panel were sharp and well-defined, and no distortion, displacement, fading, or irregularities were observed. The consistency of both the photograph and signature panel across the samples reflects the standardized personalization process employed during PAN card issuance (Ellen, 2006).

e) Observations under Hand Lens

Examination using a hand lens enabled closer inspection of surface-level printing features and provided enhanced visualization of fine details that were not readily observable with the unaided eye. All printed characters appeared sharp, continuous, and well-formed, with clearly defined edges and uniform stroke thickness. The text exhibited consistent print quality throughout the card surface, and no evidence of broken strokes, blurred characters, or irregular print formation was observed. The font style, font size, character spacing, and line alignment remained consistent among all samples. Particular attention was given to variable data fields such as the PAN number, cardholder's name, and date of birth. These fields displayed precise alignment and uniform spacing, suggesting accurate digital printing and data integration. No 15 Results indications of overwriting, erasure, correction marks, surface disturbance, or manual alteration were detected. Similarly, no signs of ink spreading, feathering, smudging, or contamination were observed. Overall, hand lens examination revealed a high degree of consistency and print integrity in all samples (Hilton, 1982).

f) Stereomicroscopic Observations

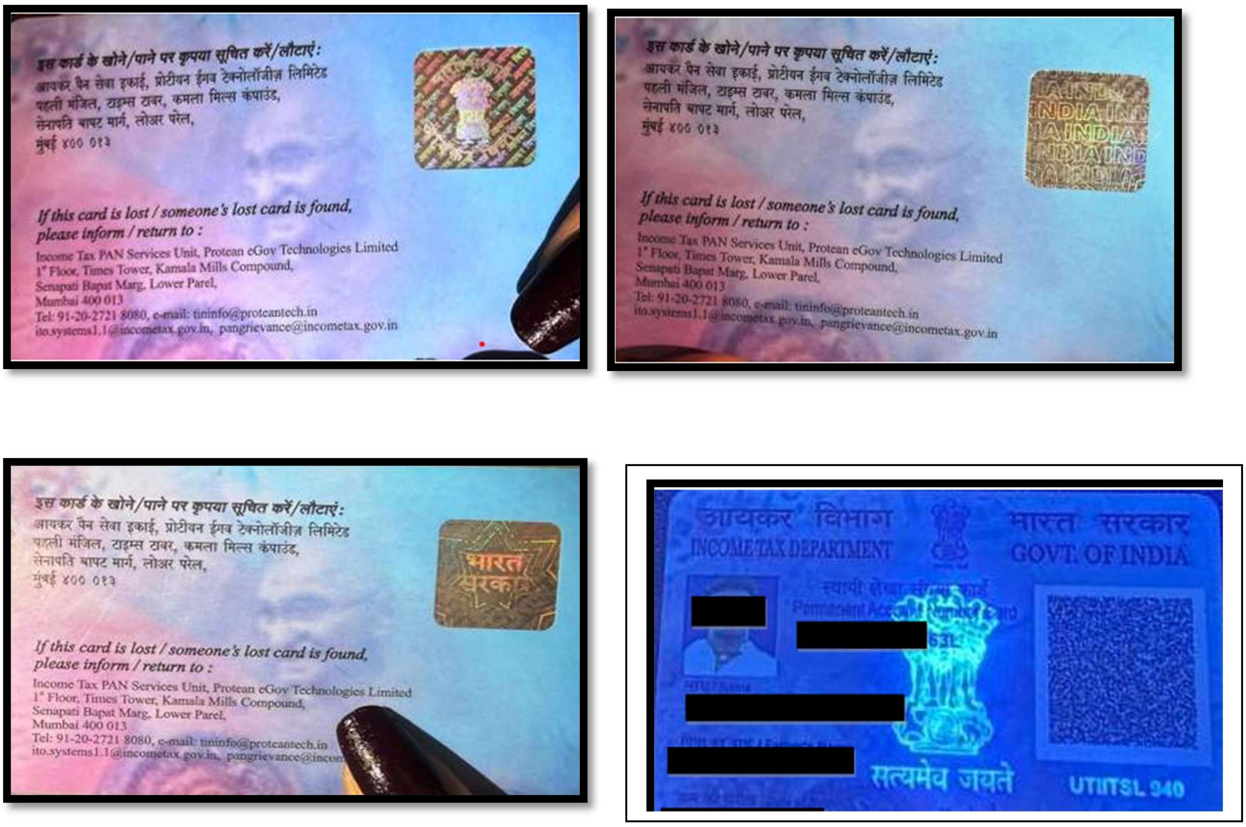
Detailed examination under a stereomicroscope provided valuable information regarding the microscopic characteristics of the printed features and card surface. The printed regions exhibited uniform deposition of toner particles, resulting in a consistent appearance throughout the examined areas. No patchiness, clustering, voids, or uneven distribution of toner particles was observed. The density of printed characters remained uniform, indicating controlled printing conditions and proper toner transfer during production. The edges of printed characters appeared sharp and distinctly demarcated from the surrounding substrate. No evidence of feathering, diffusion, spreading, or migration of toner particles was observed. Stroke continuity was maintained throughout the printed text, and the individual character structures appeared intact and well-defined. Fine granular structures characteristic of high-resolution printing technology were visible under magnification, confirming the quality of the printing process. Further examination of the card surface did not reveal any indications of physical alteration. There was no evidence of abrasion, scraping, scratching, erasure, overwriting, or other forms of mechanical disturbance. The printed layer remained continuous and undisturbed, and no disruption of the substrate surface was observed. The stereomicroscopic findings therefore support the conclusion that the examined samples retained their original printed characteristics without visible signs of tampering or modification (Hilton, 1982).

g) Ultraviolet (UV) Examination

Ultraviolet examination was conducted to assess the fluorescence characteristics and security-related responses of the PAN card samples. Upon exposure to ultraviolet radiation, specific regions of the cards exhibited distinct fluorescent behaviour. The fluorescence response was clearly visible and remained consistent among all examined samples. The intensity and distribution of fluorescence did not show any significant 16 Results variation, indicating uniform incorporation of fluorescent features during manufacturing. The background areas displayed a homogeneous luminescent effect under UV illumination. No localized suppression, enhancement, discontinuity, or irregular fluorescence pattern was observed. The luminescent response appeared evenly distributed throughout the designated regions of the cards. Furthermore, comparison among the samples revealed similar fluorescence behaviour, with no abnormal or unexpected responses detected. The consistency of UV characteristics suggests adherence to standardized production specifications and supports the authenticity of the examined security features (van Renesse, 2005).

h) Hologram Observations

The holograms present on all PAN card samples were examined under varying illumination and viewing conditions to assess their optical characteristics. When illuminated using a directed light source, the holographic elements exhibited dynamic optical effects that changed according to the viewing angle. Variations in colour, brightness, and pattern visibility were observed as the cards were tilted, producing the characteristic visual behaviour associated with security holograms. Detailed examination revealed the presence of microtext elements embedded within the holographic structure. These microtext features were not readily visible under normal lighting conditions but became apparent when the card was viewed at specific angles under directed illumination. The visibility of different microtext elements changed with alterations in viewing position, demonstrating the angle-dependent nature of the holographic security feature. Comparison of all examined samples revealed a high degree of consistency in holographic appearance, optical behaviour, and microtext visibility patterns. No significant variation in hologram quality, positioning, or response to illumination was detected. The observed characteristics are indicative of standardized holographic security features incorporated during PAN card production and serve as important indicators of document authenticity (van Renesse, 2005).



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(Figure – 1, 2, 3 shows the Pan card observed at different angles under oblique light and Figure 4 shows Pan card observed under UV light)

IV. CONCLUSION

The present study was undertaken to examine the physical and printing characteristics of genuine PAN cards and to evaluate their forensic significance in document authentication. The findings revealed a high degree of consistency among the examined samples with respect to their physical construction, layout design, printing quality, ultraviolet responses, and holographic security features. All PAN card samples exhibited standardized dimensions, a laminated polymeric substrate, clear and well-defined printing, and uniform placement of essential information. Microscopic examination confirmed the presence of sharp character formation and consistent toner deposition, with no evidence of tampering, overwriting, or other forms of alteration. Furthermore, ultraviolet examination demonstrated reproducible fluorescence patterns, while hologram analysis revealed characteristic optical variability and microtext features that serve as important indicators of authenticity. The study highlights the value of a systematic and multi-technique approach in the forensic examination of PAN cards. Physical inspection, microscopic analysis, UV examination, and hologram evaluation collectively provide reliable means for distinguishing genuine documents from forged or altered ones. Since these techniques are largely non-destructive and relatively simple to perform, they can be effectively employed in routine forensic investigations and document verification procedures. Overall, the results establish important reference characteristics of authentic PAN cards and reinforce their usefulness in forensic document examination. The findings may assist forensic experts, law enforcement agencies, and verification authorities in detecting document fraud, identity theft, and counterfeiting. Future studies involving a larger sample size and comparative analysis of counterfeit PAN cards may further enhance the understanding of document security features and strengthen authentication practices

V. REFERENCES

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