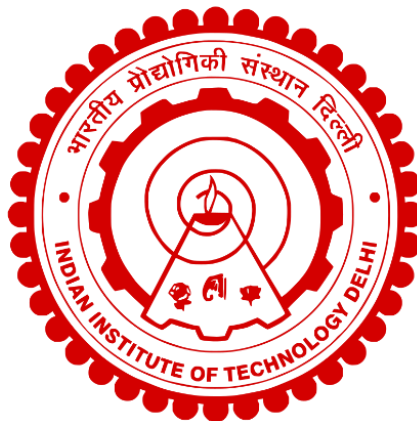


**ENHANCING JUDICIAL EFFICIENCY IN INDIA: A
PROCESS-DRIVEN APPROACH TO THE LEGAL SYSTEM**

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**Enhancing Judicial Efficiency in India: A Process-Driven
Approach to the Legal System**

by

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Dedication

To, Amma and Nanna, my first teachers, my forever motivation

(అమ్మకు, నాన్నకు, నా ప్రతీ విజయం మీ ఆశీస్సుల ప్రతిఫలమే)

My Teachers, Mentors, and Spiritual Gurus for their invaluable guidance & wisdom,

And to Almighty GOD for endless blessings, strength, and grace.

Certificate

This is to certify that the thesis entitled “**Enhancing Judicial Efficiency in India: A Process-driven Approach to the Legal System**”, being submitted by **Mr. Sri Harsha Dorapudi** to the **Indian Institute of Technology Delhi**, for the award of the degree of **Doctor of Philosophy in Mechanical Engineering**, is a record of the original, bonafide research work carried out by him under our supervision. The thesis has met the standards required to fulfill the regulations related to the award of the degree. The results contained in this thesis have not been submitted in parts or in full to any other University or Institute for the award of any degree or diploma to the best of our knowledge.

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नियतं कुरु कर्म त्वं कर्म ज्यायो ह्यकर्मणः।

“Perform your duty, for action is superior to inaction.”

- Bhagavad Gita 3.8

Sri Harsha Dorapudi

Abstract

The Indian Judiciary, one of the most extensive and complex legal systems globally, continues to face systemic inefficiencies that hinder its ability to deliver timely justice. Among several forums, the Motor Accident Claims Tribunal (MACT) represents the challenges of procedural delays, bottlenecks, and the urgent need for process modernization. This research investigates these inefficiencies to develop a process-driven, technology-enabled framework that enhances judicial efficiency, accessibility, and transparency. Positioned at the intersection of law, technology, and management sciences, it demonstrates how engineering approaches can address longstanding legal challenges.

The research objectives are threefold. The first focuses on developing a comprehensive real-time legal process map for MACT cases to capture the end-to-end litigation flow from filing to disposal. This map reveals hidden complexities, redundancies, and decision points contributing to procedural delays. Using this process map, a simulator is used to verify results through analysis of input data. The second objective examines the factors influencing technology adoption within the judicial ecosystem, focusing on how legal professionals perceive and respond to digital tools for court modernization. The third proposes and validates an AI-driven legal framework that retrieves legal document information through question-and-answer mechanisms from structured legal databases, enabling professionals to make informed decisions. Specifically, the proposed Retrieval-Augmented Generation (RAG) architecture will efficiently process MACT case documents, providing contextual responses for litigants and judicial officers.

This framework integrates process mapping, simulation, technology adoption analysis, and a tailored AI-driven RAG system for MACT, representing a novel contribution to the Indian legal system. Limited previous research has established or validated a cohesive, data-driven approach for enhancing tribunal efficiency.

This study combines insights and employs a mixed-methods approach, acknowledging the complexity of the research questions and valuing diverse perspectives throughout the investigative process. Process mapping for MACT uses qualitative inputs from court observations, expert consultations, and legal document reviews. The simulation model analyzes process delays and management possibilities that shape the operations of the court system. It also highlights the potential for optimized workflows, where digital tools reduce waiting times, pendency, and litigation costs. Further, technology adoption was assessed through stakeholder surveys and interviews, and Structural Equation Modeling (PLS-SEM) was used to measure the determinants of adoption. Results identified Ease of Use and Perception and Trust as key predictors influencing judicial acceptance of digital interventions. Additionally, the Legal Expert Gemini-Integrated System – RAG (LEGIS-RAG) model, a machine learning use case, benefits from the conventional legal retrieval methods, demonstrating superior accuracy, relevance, and user satisfaction, thereby validating intelligent query handling in practical applications.

This study offers both theoretical and practical contributions. Practically, the validated MACT process map serves as a diagnostic tool for courts, policymakers, and administrators. The simulation model identifies bottlenecks and supports targeted improvements, while SEM findings inform digital adoption strategies emphasizing trust-building, training, and user-friendly design. To support the modernization of court systems, the Retrieval-Augmented Generation architecture presents an opportunity to advance the development of an intelligent, domain-specific assistant, as demonstrated by the handling of legal case documents in MACT. Theoretically, the research enriches literature on legal process reform and technology adoption in developing judicial systems, presenting a replicable model for similar domains.

Aligned with initiatives such as India's e-Courts Mission Mode Project and the UN Sustainable Development Goals (SDGs 9 and 16), the study promotes innovation, justice, and institutional

strength. It underscores the need for comprehensive reform that integrates technology with institutional capacity-building to address case backlogs, jurisdictional inconsistencies, and infrastructural gaps. Continuous training, digital infrastructure enhancement, and stakeholder engagement are vital to ensure sustainability and inclusivity.

Finally, this research contributes to the development of a responsive, citizen-centric, and data-driven judiciary. By integrating process-driven methodologies such as workflow analysis, systems modeling, and AI-based decision support, it offers innovative solutions to inefficiency and inaccessibility. The findings provide a roadmap for policymakers and judicial administrators to strengthen the foundation of law-technology integration, transforming India's judiciary into a more efficient, transparent, and accessible system for all.

Keywords: Motor Accident Claims Tribunal (MACT), Process mapping, Technology adoption, Partial Least Squares Structural Equation Modeling (PLS-SEM), Retrieval – Augmented Generation (RAG), Sustainable Development Goals (SDGs), Judicial Efficiency, Court modernization.

सार

भारतीय न्यायपालिका, जो विश्व की सबसे व्यापक और जटिल कानूनी प्रणालियों में से एक है, वर्तमान में ऐसी प्रणालीगत अक्षमताओं का सामना कर रही है जो समय पर न्याय प्रदान करने की क्षमता में बाधा डालती हैं। विभिन्न मंचों के बीच, मोटर दुर्घटना दावा न्यायाधिकरण (MACT) प्रक्रियात्मक देरी, बाधाओं और प्रक्रिया आधुनिकीकरण की तत्काल आवश्यकता जैसी चुनौतियों का प्रतिनिधित्व करता है। यह शोध एक 'प्रक्रिया-संचालित' और 'तकनीक-सक्षम' ढांचा (Framework) विकसित करने के लिए इन अक्षमताओं की जांच करता है, जो न्यायिक दक्षता, सुलभता और पारदर्शिता को बढ़ा सके। कानून, प्रौद्योगिकी और प्रबंधन विज्ञान के संगम पर स्थित यह अध्ययन प्रदर्शित करता है कि कैसे इंजीनियरिंग दृष्टिकोणों के माध्यम से पुरानी कानूनी चुनौतियों का समाधान किया जा सकता है।

इस शोध के तीन प्रमुख उद्देश्य हैं। पहला, MACT मामलों के लिए एक व्यापक रियल-टाइम 'लीगल प्रोसेस मैप' विकसित करना, जो फाइलिंग से निपटान तक के संपूर्ण मुकदमेबाजी प्रवाह को दर्शाता है। यह मानचित्र उन छिपी हुई जटिलताओं और रेडडेंसी (अनावश्यक दोहराव) को उजागर करता है जो विलंब का कारण बनती हैं। इस प्रोसेस मैप का उपयोग करते हुए, इनपुट डेटा के विश्लेषण के माध्यम से परिणामों को सत्यापित करने के लिए एक 'सिम्युलेटर' का प्रयोग किया गया है। दूसरा उद्देश्य न्यायिक परितंत्र के भीतर प्रौद्योगिकी अपनाने को प्रभावित करने वाले कारकों की जांच करना है, जिसका ध्यान इस बात पर है कि कानूनी पेशेवर अदालत के आधुनिकीकरण के लिए डिजिटल उपकरणों के प्रति कैसी प्रतिक्रिया देते हैं। तीसरा उद्देश्य

एक AI-संचालित कानूनी ढांचे का प्रस्ताव और सत्यापन करना है, जो संरचित कानूनी डेटाबेस से प्रश्न-उत्तर तंत्र के माध्यम से जानकारी प्राप्त करता है। विशेष रूप से, प्रस्तावित रिट्रीवल-ऑगमेंटेड जनरेशन (RAG) आर्किटेक्चर MACT केस दस्तावेजों को कुशलतापूर्वक प्रोसेस करेगा, जो वादियों और न्यायिक अधिकारियों के लिए प्रासंगिक प्रतिक्रियाएं प्रदान करेगा।

यह शोध ढांचा MACT के लिए प्रक्रिया मानचित्रण (Process Mapping), सिमुलेशन, प्रौद्योगिकी अपनाने के विश्लेषण और एक विशेष रूप से तैयार AI-संचालित RAG सिस्टम को एकीकृत करता है, जो भारतीय कानूनी प्रणाली में एक नवीन योगदान है। इस अध्ययन में 'मिश्रित-विधि दृष्टिकोण' (Mixed-methods approach) को नियोजित किया गया है। MACT के लिए प्रक्रिया मानचित्रण में अदालती टिप्पणियों, विशेषज्ञ परामर्श और कानूनी दस्तावेजों की समीक्षा से गुणात्मक इनपुट लिए गए हैं। सिमुलेशन मॉडल प्रक्रिया में होने वाली देरी और प्रबंधन की संभावनाओं का विश्लेषण करता है। इसके अलावा, हितधारकों के सर्वेक्षणों के माध्यम से प्रौद्योगिकी अपनाने का मूल्यांकन किया गया और स्ट्रक्चरल इक्वेशन मॉडलिंग (PLS-SEM) का उपयोग करके इसे मापा गया। परिणामों ने 'उपयोग में आसानी' (Ease of Use) और 'धारणा एवं विश्वास' (Perception and Trust) को डिजिटल हस्तक्षेपों की न्यायिक स्वीकृति को प्रभावित करने वाले प्रमुख कारकों के रूप में पहचाना। इसके अतिरिक्त, LEGIS-RAG (Legal Expert Gemini-Integrated System – RAG) मॉडल ने पारंपरिक कानूनी पुनर्प्राप्ति विधियों की तुलना में बेहतर सटीकता और उपयोगकर्ता संतुष्टि का प्रदर्शन किया।

यह अध्ययन सैद्धांतिक और व्यावहारिक दोनों योगदान देता है। व्यावहारिक रूप से, मान्य MACT प्रक्रिया मानचित्र अदालतों और नीति निर्माताओं के लिए एक नैदानिक उपकरण (Diagnostic tool) के रूप में कार्य करता है। सैद्धांतिक रूप से, यह शोध विकासशील न्यायिक प्रणालियों में कानूनी प्रक्रिया सुधार और प्रौद्योगिकी अपनाने पर साहित्य को समृद्ध करता है। भारत के 'ई-कोर्ट मिशन मोड प्रोजेक्ट' और संयुक्त राष्ट्र के सतत विकास लक्ष्यों (SDG 9 और 16) के अनुरूप, यह अध्ययन नवाचार, न्याय और संस्थागत मजबूती को बढ़ावा देता है। अंततः, यह शोध एक जवाबदेह, नागरिक-केंद्रित और डेटा-संचालित न्यायपालिका के विकास में योगदान देता है। वर्कफ़्लो विश्लेषण, सिस्टम मॉडलिंग और AI-आधारित निर्णय समर्थन जैसी विधियों को एकीकृत करके, यह अक्षमता और दुर्गमता के नवीन समाधान प्रदान करता है। ये निष्कर्ष नीति निर्माताओं और न्यायिक प्रशासकों के लिए कानून-प्रौद्योगिकी एकीकरण की नींव को मजबूत करने और भारत की न्यायपालिका को सभी के लिए अधिक कुशल, पारदर्शी और सुलभ बनाने हेतु एक रोडमैप प्रदान करते हैं।

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मोटर दुर्घटना दावा न्यायाधिकरण (MACT), प्रक्रिया मानचित्रण (Process mapping), प्रौद्योगिकी अपनाना (Technology adoption), पार्शियल लीस्ट स्क्वायर्स स्ट्रक्चरल इक्वेशन मॉडलिंग (PLS-SEM), रिट्रीवल-ऑगमेंटेड जनरेशन (RAG), सतत विकास लक्ष्य (SDGs), न्यायिक दक्षता, न्यायालय आधुनिकीकरण।

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List of Abbreviations

Abbreviation	Definition
AB	Awareness Building
ADR	Alternative Dispute Resolution
AI/ML	Artificial Intelligence / Machine Learning
AI	AI-Integration
AQAF	Augmented Question Answering Framework
AUI	Automation Issues
BPR	Business Process Reengineering
BRUSO	Brief, Relevant, Unambiguous, Specific, Objective
CIDP	Cybersecurity, Infrastructure, and Data Protection
CFA	Confirmatory factor analysis
CO	Community Outreach
CTO	Confidence in Technology Use
CVR	Content Validity Ratio
DAR	Detailed Accident Report
DIAC	Delhi International Arbitration Centre
DS	Digital tools and IT Systems
EFA	Exploratory Factor Analysis
EOU	Ease of Use
EP	Educational Programs
FAR	First Accident Report
FT	Familiarity with Technology
FU	Frequency of Use

FQT	Frequency of Training
HC	High Court
HRU	Human Resource Upgrades
ICT	Information Communication Technology
I-CVI	Item Content Validity Index
IE	Information and Education
IFU	Issue of fairness in use
IU	Infrastructure Upgrades
JE	Judicial Efficiency
LEGIS – RAG	Legal Expert Gemini-Integrated System - RAG
LLMs	Large Language Models
MACAD	Motor Accident Claim Annuity Deposit
MACT	Motor Accident Claim Tribunal
MCIA	Mumbai Centre for International Arbitration
NALSA	National Legal Services Authority
NFI	Normed Fit Index
NJDG	National Judicial Data Grid
NLP	Natural Language Processing
PLS	Partial Least Squares
PR	Procedural revamping
PT	Perception and Trust
PU	Promptness of Use
QAS	Question Answering Systems
QT	Quality of Training

RAG	Retrieval Augment Generation
RO	Research Objective
SCI	Supreme Court of India
SDG	Sustainable Development Goals
SEM	Structural Equation Modeling
SMILE+IBP	SMart Index Learner Plus Issue-Based Prediction
SRMR	Standardized Root Mean Square Residual
TA	Technology accessibility
TAJ	Technology Adoption in the Judiciary
TE	Task Efficiency
TT	Trust in Technology
TTFT	Time to First Token
TFN	Training and Future Needs
WAN	Wide Area Network