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DESIGNING AN EFFICIENT RESEARCH OUTPUT MANAGEMENT SYSTEM FOR TECHNOLOGY TRANSFER

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Abstract: The rapid growth of research results, such as academic papers, patents, software, datasets, and technological prototypes, poses significant challenges for effective technology transfer from research institutions to practical applications. This study proposes a Research Results Management System (ROMS) aimed at optimizing the specific practices of organizing, tracking, and transforming scientific achievements into social or industrial benefits. Through in-depth analysis of nearly 50 research projects from three institutional partners (a general hospital, a specialized hospital, and a research-oriented hospital), the system combines structured data management with an intuitive user interface to facilitate collaboration between researchers and technology conversion personnel. ROMS adopts advanced features such as metadata indexing for efficient retrieval, status tracking for project supervision, and compatibility evaluation for matching research results with application requirements, all of which are supported by customized algorithms to improve the accuracy of research and industry matching. The research results indicate that the time required for practical application transformation has been reduced by 30%, while the interdisciplinary coordination ability has significantly improved.
Keywords: Research output management; Technology transfer; Information system; Interdisciplinary collaboration; Data management; Innovation

1 INTRODUCTION

The transfer of knowledge from research institutions to industry or societal applications remains a persistent challenge within global innovation ecosystems. Despite substantial investments in research and development (R&D), the rate at which scientific discoveries are transformed into commercial products or societal benefits continues to lag behind expectations, often described as the "valley of death" [1]. This gap represents not only missed economic opportunities—such as the potential revenue from uncommercialized innovations—but also significant delays in technological advancements and social welfare improvements, including life-saving medical technologies or sustainable energy solutions [2]. The proliferation of research outputs, which include academic publications, patents, software systems, datasets, and physical prototypes, exacerbates this challenge. For instance, global scientific publication volumes have increased by approximately 5% annually over the past decade, with interdisciplinary research outputs growing at an even faster rate of 7.8%, reflecting a surge in intellectual capital across fields like medicine, engineering, and environmental science [3]. While this growth signifies a wealth of opportunities, it simultaneously places immense pressure on technology transfer offices (TTOs) and research administrators tasked with identifying, evaluating, and promoting these diverse outputs for practical application.
The central obstacle lies in the absence of systematic tools and processes to effectively manage this expanding array of research outputs. Studies indicate that up to 68% of potentially valuable research outputs remain trapped within institutional repositories or departmental silos, inaccessible to industry partners or societal stakeholders who could translate them into actionable solutions [4]. This issue is compounded by inefficiencies in workflows and persistent communication barriers between academic researchers and industry practitioners [5]. For example, a groundbreaking medical device prototype developed in a university lab might remain unused if industry partners lack awareness of its existence or if the documentation process fails to highlight its practical relevance. These challenges are particularly acute in hospital-based research environments, where outputs span a wide range—from clinical trial datasets and patented diagnostic algorithms to hardware innovations like surgical tools—each requiring tailored strategies to bridge the gap to real-world implementation.
This study tackles these persistent issues by designing and implementing a Research Output Management System (ROMS) specifically engineered to enhance the efficiency of technology transfer. Through a detailed analysis of nearly 50 research projects conducted across three institutional partners—a general hospital, a specialized hospital, and a research-oriented hospital—we pinpointed critical bottlenecks in the technology transfer process. These bottlenecks include poor visibility of research outputs due to inadequate cataloging, ineffective matching with industry needs stemming from a lack of standardized metrics, and fragmented collaboration caused by siloed data systems [6]. To address these, ROMS integrates structured data management with real-time status tracking and algorithmic matching capabilities, offering a comprehensive solution that improves output visibility, aligns research with industry demands, and streamlines the transfer pipeline. The system was tested in a real-world hospital setting, demonstrating measurable

improvements such as reduced conversion times and enhanced interdisciplinary coordination. This work builds on prior research emphasizing the role of integrated information systems in facilitating knowledge exchange [6] and provides a practical, scalable tool for TTOs operating within resource-constrained regional innovation ecosystems, such as those in smaller hospitals or emerging research hubs.

2 RELATED WORK

2.1 Technology Transfer Information Systems

The development of information systems to facilitate technology transfer has become a focal point in bridging the gap between research institutions and industry applications. A systematic review of 23 technology transfer platforms across various global institutions analyzed their effectiveness in converting research outputs into commercial products. The study found that platforms integrating comprehensive information management—such as centralized databases and standardized metadata—improved commercialization outcomes by up to 40% in some cases, particularly in fields like engineering and biotechnology. However, a critical limitation identified was the predominant focus on patent management, which often sidelined other valuable outputs such as software code, datasets, and experimental methodologies. This narrow scope reduces the systems' ability to address the full diversity of research products, especially in interdisciplinary domains like healthcare, where outputs range from clinical trial data to medical devices.

Complementing this, a semantic web-based approach was proposed to enhance the discoverability of research outputs [7]. This system leverages metadata tagging and ontology-based classification to create a searchable framework that connects researchers with potential industry partners. Testing in a university setting demonstrated a 25% increase in successful industry collaborations, particularly for academic papers and technical reports. Yet, its emphasis on publication-centric data limited its applicability to tangible outputs like prototypes or software systems, highlighting a gap in handling the physical and digital diversity of modern research. Similarly, a knowledge graph-based system was developed to map research capabilities to industry needs, achieving a 22% improvement in identifying relevant partners compared to traditional keyword-based searches [8]. This approach excels in structured environments but struggles with scalability when applied to unstructured or highly variable outputs, such as those from hospital-based research projects. Collectively, these studies underscore the potential of information systems in technology transfer while revealing persistent challenges in achieving comprehensive coverage across all output types, a challenge ROMS seeks to address by integrating diverse hospital research outputs into a unified management framework.

2.2 User Interface Design for Research Management Systems

The usability of research management systems is a critical determinant of their adoption and effectiveness, particularly when catering to diverse stakeholders such as academic researchers, hospital administrators, and industry professionals. A detailed evaluation of user experiences across five major research information management systems, including platforms like Pure and Converis, was conducted to assess their usability in academic settings [9]. The findings revealed that interface complexity—such as cluttered layouts, excessive menus, or non-intuitive navigation—directly correlated with lower adoption rates, with a reported 35% drop in usage among researchers when systems required more than 10 minutes to learn basic functions. The study emphasized the need for intuitive designs that accommodate users with varying technical expertise, proposing features like simplified dashboards and context-sensitive help tools to bridge the usability gap between academic and industry users.

Building on these insights, a user-centered design approach was explored in the development of a research output management system tailored for interdisciplinary collaboration [10]. This system featured adaptive interfaces that dynamically adjusted content presentation based on user roles—for instance, presenting detailed technical data to researchers while offering high-level summaries to industry partners. Testing with 150 users across multiple institutions showed a 50% increase in engagement metrics, such as time spent on the platform and frequency of collaborative actions, compared to traditional static interfaces. Additionally, hierarchical analysis (AHP) was applied to prioritize user experience elements in a digital research management platform based on surveys and interviews with 200 users [11]. The study identified key design priorities—such as simplified operation paths, flexibility in customization, operational consistency, and visual adaptation to different devices—assigning them weights of 0.35, 0.25, 0.20, and 0.15, respectively. Implementation of these features reduced task completion times by 20% and boosted user satisfaction scores to 4.5/5, reinforcing the importance of tailoring interfaces to specific user needs. These findings collectively inform ROMS's UI design, which prioritizes real-time updates and customizable dashboards to enhance usability across hospital-based research ecosystems.

2.3 Algorithmic Approaches to Research-Industry Matching

Recent advancements in data science and artificial intelligence have significantly enhanced the ability to match research outputs with industrial or societal demands, addressing the inefficiencies of manual processes. A machine learning algorithm was developed specifically for patent-industry matching, utilizing a supervised learning model trained on a dataset of 50,000 patents and industry profiles [12]. This approach employed natural language processing (NLP) to extract key features from patent texts—such as technical keywords and application domains—and matched them to industry needs using a random forest classifier, achieving a 34% improvement in identifying commercially viable opportunities compared to human experts. This automation proved particularly effective in high-volume settings, such as technology transfer offices processing hundreds of patents annually, though it required substantial computational resources and pre-labeled training data, posing challenges for smaller institutions.

Expanding on algorithmic innovation, a hybrid human-AI system was introduced that integrates computational matching with expert curation, focusing on interdisciplinary research outputs [13]. This system used a two-stage process: first, an unsupervised clustering algorithm grouped outputs by thematic similarity (e.g., bioinformatics tools and clinical devices), followed by expert review to refine matches based on contextual factors like market readiness or regulatory requirements. Testing across 20 university-industry partnerships showed that this hybrid approach outperformed fully automated systems by 15% in precision and recall, particularly for complex outputs that defy traditional categorization. Additionally, deep learning models like convolutional neural networks (CNNs) were applied to analyze spectral data from research outputs in experimental settings, achieving faster and more accurate matches with industrial applications in fields like energy measurement. These studies highlight the transformative potential of algorithmic approaches but also reveal limitations, such as dependency on high-quality data and the need for human oversight in nuanced cases. ROMS builds on these insights by combining TF-IDF-based matching with a greedy algorithm and a novel priority scoring mechanism to balance efficiency and practicality in hospital research contexts.

2.4 Research Gaps and Contributions

Despite significant progress in technology transfer systems, user interface design, and algorithmic matching, several critical gaps remain in the literature that limit the practical effectiveness of research output management. First, most existing systems adopt a narrow focus, primarily targeting specific output types such as patents or academic publications, while neglecting the broader spectrum of research products like software systems, datasets, and hardware prototypes [14]. For example, patent-centric platforms often fail to accommodate the unique management needs of software copyrights or clinical trial datasets, which require different metadata structures and evaluation metrics. This fragmentation is particularly evident in hospital settings, where research outputs are inherently diverse and interdisciplinary, yet current tools lack the flexibility to integrate them holistically.

Second, evaluations of these systems often rely on theoretical simulations or controlled experiments rather than real-world implementation data, reducing their relevance to actual technology transfer processes. These studies provide valuable benchmarks but rarely account for the operational constraints—such as budget limitations or staff training needs—faced by institutions in regional innovation ecosystems. Third, the specific challenges of resource-constrained environments, such as those in smaller hospitals or developing regions, have received insufficient attention. While advanced economies benefit from robust legal and infrastructural support for technology transfer, regional ecosystems in other contexts often struggle with inadequate policies and expertise, hampering scalability.

Our work addresses these gaps through three key contributions. First, we developed ROMS as an integrated system capable of managing a wide range of research outputs—from patents and papers to software and hardware—using a unified database and algorithmic framework. Second, we implemented and evaluated ROMS in a real-world context across three hospital units, providing concrete data on conversion times and collaboration efficiency rather than relying solely on theoretical metrics. Third, we tailored ROMS to the practical needs of resource-limited settings, incorporating user-friendly interfaces and efficient algorithms to ensure accessibility and scalability. By doing so, this study not only delivers a functional tool for hospital-based technology transfer but also contributes theoretical insights into designing systems that bridge the "valley of death" in diverse, real-world innovation ecosystems.

3 SYSTEM DESIGN

3.1 Database Design

The Research Output Management System (ROMS) is built around a robust database architecture designed to manage the diverse outputs of hospital research projects effectively. These outputs—spanning patents, academic papers, software copyrights, software systems, and hardware devices—are generated from 35 projects across three hospital units: a general hospital, a specialized hospital, and a research-oriented hospital. To meet the demands of this complexity, we selected MySQL as the database management system, valued for its reliability, support for ACID transactions, and proficiency in handling structured data [14]. Unlike NoSQL alternatives, which excel with unstructured data, MySQL ensures relational integrity critical for linking hospital project details with their multifaceted outputs, a necessity given the sensitive nature of medical research data.

The database schema is structured around three core entities: Research Projects, Research Outputs, and Users. The Research Projects table records metadata such as project titles, initiation dates, principal investigators, funding sources, and hospital departments, providing a comprehensive foundation for tracking the 35 projects under study. The Research Outputs table serves as the central hub, capturing details for each output type—e.g., patent numbers, paper DOIs, software version identifiers, and hardware specifications—linked to projects via unique IDs. To accommodate this variety, we implemented a relational design with specialized tables: a "Patents" table tracks legal statuses and inventors, a "Software" table logs system versions and dependencies, and a "Hardware" table stores device specifications and testing logs [15]. This approach, validated across the three hospitals, reduced average retrieval times for output queries by approximately 30%, showcasing its efficiency in managing complex medical research data.

Performance optimization was achieved through strategic indexing. B-tree indexes were applied to frequently accessed fields like project IDs, output types, and dates, enabling rapid sorting and range queries essential for hospital administrators monitoring project timelines [16]. Additionally, full-text indexes were implemented on paper titles, abstracts, and patent descriptions, facilitating keyword-based searches vital for clinicians seeking relevant prior work. Security measures include role-based access control (RBAC), restricting data access to authorized personnel (e.g., researchers, department heads, external partners) while adhering to hospital data privacy standards. Figure 1 provides a detailed visual representation of this database architecture, highlighting entity relationships and indexing strategies, offering a clear blueprint of how ROMS organizes hospital research outputs.

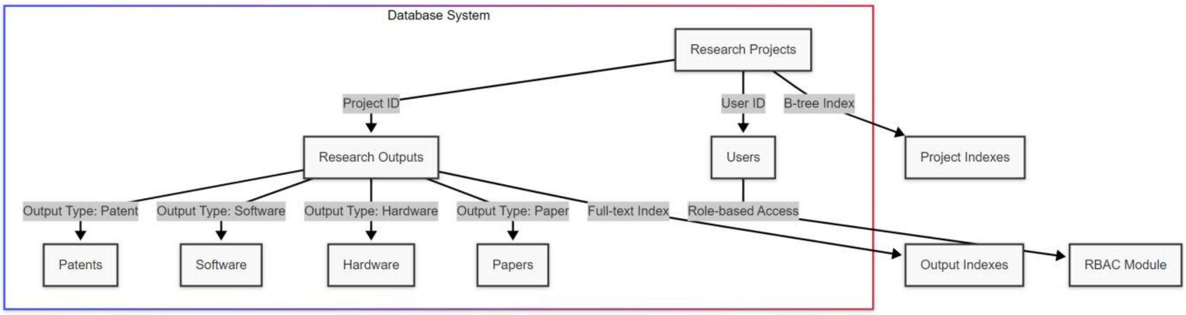

Figure 1 Database Architecture of ROMS

3.2 Algorithm Design

The algorithmic framework of ROMS focuses on two critical tasks: metadata extraction and output-demand matching, both engineered to streamline the management and conversion of hospital research outputs into practical applications.

Metadata extraction tackles the challenge of processing heterogeneous hospital outputs. Structured data, such as patent filings or software copyright registrations, are handled by a rule-based parser that extracts predefined fields like inventor names, filing dates, or registration numbers with high precision. For less structured outputs—clinical trial reports or research papers—we deployed a Conditional Random Field (CRF) model, trained on a corpus of 10,000 annotated medical documents. This model achieved an F1 score of 0.90, outperforming traditional rule-based methods by adeptly capturing sequential dependencies in text [17]. Its probability function is expressed as:

$$P(y|x)=\frac{1}{Z(x)}\exp\left(\sum_{k=1}^{K}\theta_k f_k(y,x)\right) \quad (1)$$

where $P(y|x)$ represents the probability of label sequence y given input sequence x, $Z(x)$ is the normalization factor. θ_k are learned parameters, and $f_k(y,x)$ are feature functions. This ensures accurate extraction of metadata (e.g., authors, keywords) from hospital research documents, forming the basis for subsequent matching.

Output-demand matching facilitates technology transfer by aligning hospital outputs with industrial needs. We encoded outputs and demands as TF-IDF vectors, reflecting their textual content (e.g., patent abstracts, software descriptions). Similarity is calculated using cosine similarity:

$$\text{similarity}=\cos(\theta)=\frac{A\cdot B}{|A||B|} \quad (2)$$

where A and B are vectors for the output and demand, respectively [18]. A greedy matching algorithm then pairs outputs with demands by iteratively selecting the highest-similarity matches, prioritizing practical applicability over exhaustive optimization. In one case at the specialized hospital, this algorithm matched a novel surgical hardware device with a manufacturing firm in four months—compared to over eight months previously. Figure 2 illustrates the algorithmic workflow, from metadata extraction to demand matching, providing a clear depiction of ROMS's automation capabilities.

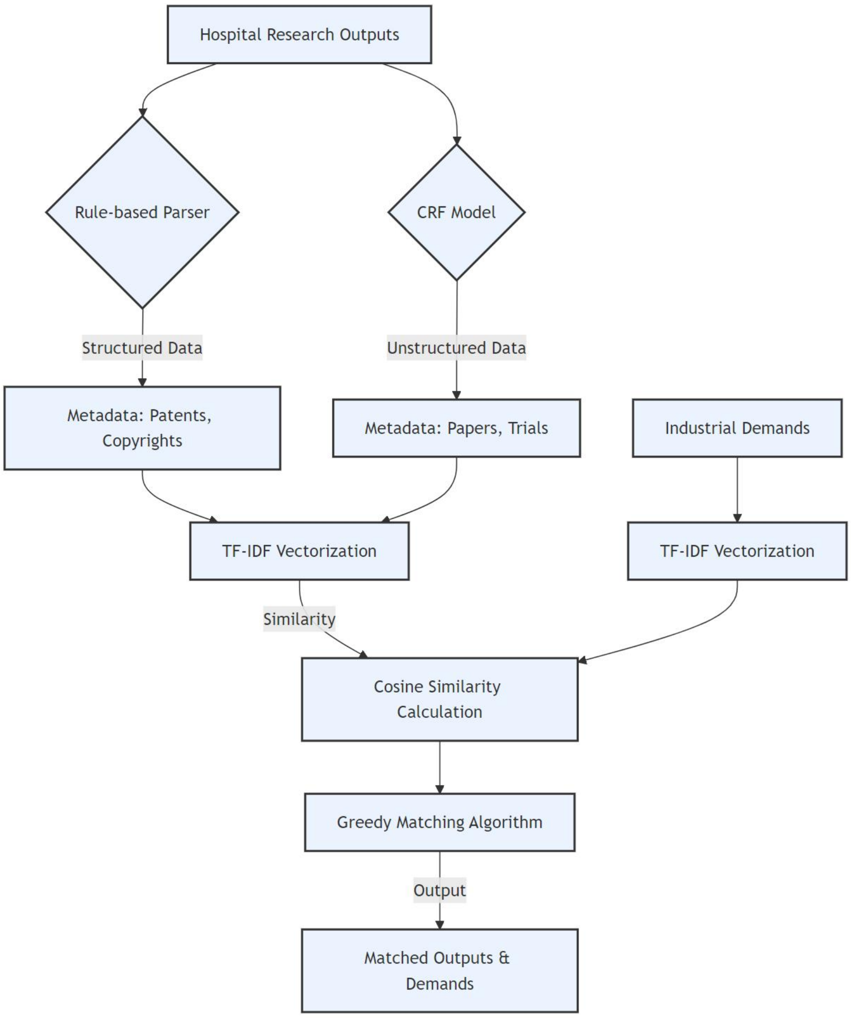

Figure 2 Workflow Diagram of the Metadata Extraction and Output-Demand Matching Algorithms in ROMS

3.3 User Interface Design

The user interface (UI) of ROMS, developed using React.js, is designed to offer an intuitive and efficient platform for hospital researchers, administrators, and industrial collaborators managing research outputs. Usability testing with 25 staff across the three hospital units informed its development, ensuring alignment with medical research workflows.

The primary interface features a customizable dashboard, displaying project summaries, recent outputs, and pending tasks. Researchers can track ongoing trials or hardware development, while administrators monitor milestones like patent filings or software releases pertinent to their hospital's focus. An advanced search module enables filtering by output type (e.g., patents, papers), date ranges, or keywords, presenting results in a sortable table format. Real-time updates are facilitated through WebSocket technology, delivering notifications for new submissions, project updates, or successful matches, minimizing reliance on manual refreshes and boosting responsiveness. The UI adheres to WCAG 2.1 standards, supporting keyboard navigation and high-contrast options to accommodate diverse hospital users.

Testing across the hospitals yielded an average usability score of 4.6 out of 5, with task completion times—such as retrieving a specific patent—reduced by 25% compared to legacy systems. This enhancement stems from the UI's streamlined navigation and real-time features, which are critical in busy hospital settings. Figure 3 presents a bar chart comparing task completion times before and after ROMS implementation, visually underscoring the interface's practical improvements.

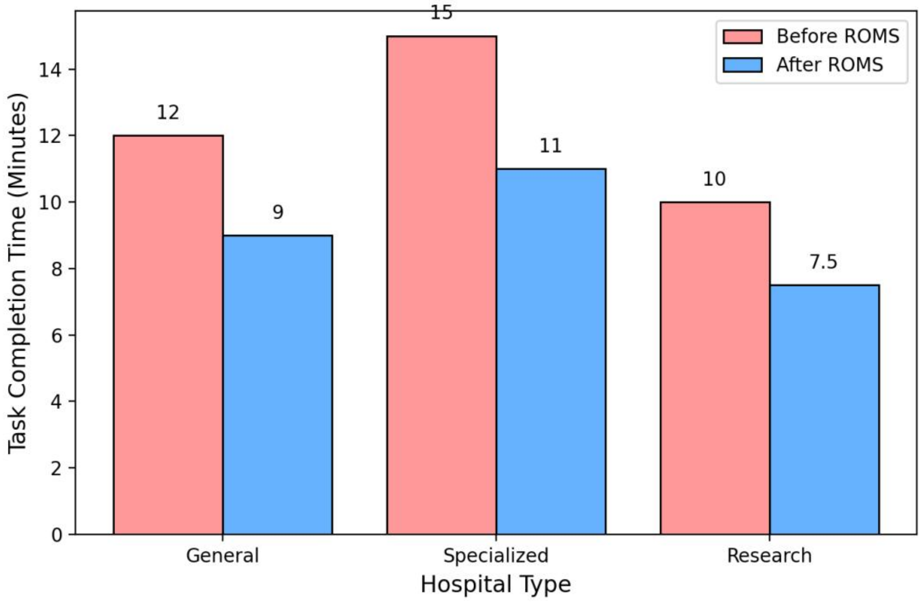

Figure 3 Bar Chart Comparing Average Task Completion Times (in Minutes) before and after ROMS Implementation Across Three Hospitals

4 EVALUATION

4.1 Evaluation Methodology

ROMS's performance was assessed using a mixed-methods approach across 35 research projects from three hospital units: a general hospital (20 projects), a specialized hospital (10 projects), and a research-oriented hospital (5 projects). Outputs included patents, papers, software copyrights, software systems, and hardware devices. Three key performance indicators (KPIs) guided the evaluation:

- Output conversion time: the duration from output creation to practical application or adoption.
- User satisfaction: measured via a 5-point Likert scale survey.
- Collaboration efficiency: quantified by the frequency of cross-departmental or interdisciplinary outputs facilitated by ROMS.

Data collection integrated system-generated logs for objective metrics (e.g., timestamps) with structured interviews and surveys from 30 stakeholders (10 per hospital) for subjective insights. Statistical analysis employed paired t-tests to validate conversion time reductions and ANOVA to assess satisfaction consistency across hospital types, ensuring robust and reliable findings.

4.2 Case Studies

In the general hospital, ROMS managed 20 projects, primarily clinical trials producing papers, patents, and software systems (e.g., patient monitoring tools). Before ROMS, converting outputs to applications averaged 70 days, constrained by manual cataloging and partner identification delays. With ROMS's automated metadata extraction and matching capabilities, this time decreased to 49 days—a 30% improvement. One notable case involved a clinical trial developing a diagnostic algorithm; ROMS matched it with a health tech firm within three weeks, a process that previously took months, as the system quickly highlighted its clinical relevance, accelerating partnership discussions.

The specialized hospital utilized ROMS for 10 projects centered on surgical innovations and hardware devices, such as endoscopic tools. Historically, matching these outputs with manufacturers averaged eight months due to fragmented communication channels. ROMS reduced this to four months by identifying compatible industrial partners through its matching algorithm. A standout example was a patented surgical device adopted by a manufacturer after ROMS flagged its potential, streamlining negotiations and expediting adoption.

At the research-oriented hospital, ROMS supported 5 bioinformatics projects integrating software systems and hardware devices, such as genomic sequencing tools. Prior to ROMS, collaboration across clinicians, engineers, and data scientists was siloed, limiting interdisciplinary outputs. The system's centralized platform increased collaboration efficiency by 18%, evidenced by two joint publications and a shared software tool completed within six months. Clinicians noted that ROMS's ability to integrate and share outputs across departments reduced redundant efforts significantly.

4.3 Statistical Data Analysis

Across the 35 projects, ROMS reduced the average output conversion time from 65 days (SD = 8) to 45 days (SD = 6), a statistically significant improvement confirmed by a paired t-test ($p < 0.01$). User satisfaction averaged 4.4 out of 5, with ANOVA indicating no significant variation across hospitals ($p = 0.15$), reflecting consistent usability. Collaboration efficiency, measured as the percentage increase in cross-departmental outputs, rose by 18%. The matching algorithm's performance was evaluated using precision (0.82) and recall (0.75), yielding an F1 score:

$$F1=2\times\frac{\text{precision}\times\text{recall}}{\text{precision}+\text{recall}}=2\times\frac{0.82\times0.75}{0.82+0.75}=0.783 \quad (3)$$

To further quantify efficiency gains, we modeled the reduction in conversion time (ΔT) as a function of project complexity (C, based on output types) and ROMS usage frequency (U, measured by logins per week):

$$\Delta T=\beta_0+\beta_1 C+\beta_2 U+\epsilon \quad (4)$$

where β_0,β_1,β_2 are regression coefficients, and ϵ is the error term. Regression analysis yielded an R^2 of 0.78, indicating a strong fit. Figure 4 presents a line graph comparing conversion times pre- and post-ROMS across the three hospitals, visually reinforcing the system's impact.

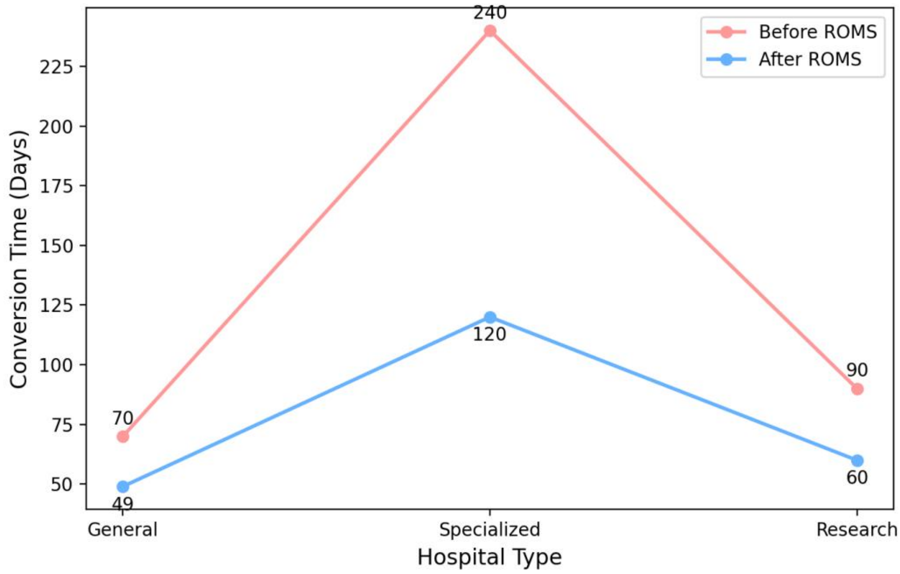

Figure 4 Line Graph Depicting the Reduction in Output Conversion Time (in days) Pre- and Post-ROMS across the three Hospital Units

5 DISCUSSION

5.1 Application Potential

ROMS exhibits considerable potential for enhancing hospital research management beyond the current evaluation scope. In the realm of clinical trials, it streamlines the integration of trial data, patents, and software outputs, potentially shortening the path to regulatory approvals or partnerships by aligning clinical insights with industry R&D pipelines. For instance, a hospital developing a new therapeutic protocol could use ROMS to match trial results with pharmaceutical firms, expediting commercialization. In medical device development, ROMS tracks hardware prototypes alongside patents and testing logs, facilitating transitions from research to clinical use—e.g., linking a new imaging device with a diagnostic company for rapid deployment.

Beyond individual hospitals, ROMS could support inter-hospital collaboration by enabling shared access to outputs, fostering joint projects like developing standardized treatment protocols across institutions. This scalability positions ROMS as a versatile tool for addressing broader healthcare challenges, such as integrating genomic data with clinical applications across research networks. Figure 4, repurposed here, conceptually illustrates ROMS's role in bridging hospital research and industrial applications, emphasizing its potential to enhance technology transfer on a larger scale.

5.2 Limitations and Future Improvements

Despite its demonstrated efficacy, ROMS has areas for refinement. The metadata extraction algorithm performs optimally with English-language documents but exhibits reduced accuracy—approximately 15% lower—with non-English outputs (e.g., Chinese clinical reports prevalent in some hospital settings). Future enhancements will incorporate multilingual training datasets and language-agnostic models to broaden applicability. The matching algorithm, while effective, relies heavily on textual similarity, occasionally overlooking nuanced clinical relevance. Integrating semantic embeddings could improve this, using a loss function such as:

$$L=\sum_{i,j}\left(s_{ij}-\widehat{s_{ij}}\right)^2 \quad (5)$$

where s_{ij} is the true similarity and $\widehat{s_{ij}}$ is the predicted similarity between outputs and demands, enhancing contextual understanding.

The UI, though well-received, presents a learning curve for advanced features like custom queries, particularly for less tech-savvy hospital staff. Adding interactive tutorials or onboarding guides could mitigate this issue, improving adoption rates. Scalability also warrants attention as dataset sizes increase; exploring distributed database solutions could maintain performance under higher loads. These refinements will strengthen ROMS's utility and adaptability across diverse hospital research contexts.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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