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Binary Logic as Legal Algorithm: Computational Evidence of Systematic Decision-Making in Ottoman Sheikh al-Islam Fatwas

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Abstract: Bridging computational linguistics, machine learning, and Islamic legal studies, this interdisciplinary investigation examines the algorithmic structure underlying Ottoman Sheikh al-Islam fatwa reasoning. Analysis of 9,913 fatwas from authoritative collections—including Fetâvâ-yı Feyziye, Fetâvâ-yı Ebüssuûd Efendi, and Behcetü'l-Fetâvâ—establishes that nearly 87% of rulings follow binary prohibition/permission logic. This binary architecture exhibits notably low entropy (1.599 bits), falling 66% below maximum possible entropy, which suggests highly structured decision patterns characteristic of the centralized Sheikh al-Islam authority. Machine learning models achieved considerable predictive accuracy (87.6% with XGBoost), with simple linguistic markers ("olmaz"/"olur") emerging as the strongest predictors. Among binary cases, prohibitions (4,410) and permissions (4,199) appear balanced, challenging assumptions about Islamic law's supposedly restrictive nature. Financial matters pointed to even higher binary classification rates than non-financial cases (88% versus 84%), likely reflecting commercial law's demand for clear guidance. Such systematic patterns, developed centuries before digital computing, suggest that algorithmic legal reasoning may represent an ancient practice rather than a modern innovation. These results carry implications for contemporary debates around legal automation and the appropriate role of Artificial Intelligence (AI) in religious jurisprudence, while documenting how pre-modern institutions achieved systematization through human rather than technological means.

Keywords: Sheikh al-Islam, Ottoman Fatwas, Computational Jurisprudence, Islamic Law, Legal Algorithms, Binary Logic, Machine Learning.

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Yasal Bir Algoritma Olarak İkili Mantık: Osmanlı Şeyhulislam Fetvalarında Sistematik Karar Vermenin Hesaplanabilir Kanıtları

Özet: Bu disiplinlerarası araştırma, Osmanlı şeyhülislamlarının fetva mantığının temelindeki algoritmik yapıyı açığa çıkarmak amacıyla hesaplamalı dilbilim, makine öğrenmesi, İslam hukuku ve bilgi teorisi arasında bir köprü kurmaktadır. Fetâvâ-yı Feyziye, Fetâvâ-yı Ebüssuûd Efendi ve Behcetü'l-Fetâvâ gibi otoriter kaynaklardan seçilen 9.913 fetvanın incelenmesi sonucunda, İslam hukukunun özünde ikili bir algoritmik düzen üzerine işlediği ve kararların %86,8'inin "yasaklama/izin" mantığına dayandığı ortaya konmuştur. Sistem, olası en yüksek entropi düzeyi olan 4.755 bitten %66,4 oranında daha düşük bir seviyeyi temsil eden 1.599 bitlik dikkat çekici bir düşük entropi sergilemektedir. Bu durum, Osmanlı'daki şeyhülislamlık kurumunun merkezinde gelişen hukuk hiyerarşisinin, oldukça yapılandırılmış ve öngörülebilir karar kalıpları ürettiğini göstermektedir. Makine öğrenmesi modelleri, fetvaları tahmin etmede %87,6 doğruluk oranına (XGBoost) ulaşmakta; özellikle "olur/olmaz" gibi ikili dilsel işaretler en güçlü belirleyici öğeler olarak öne çıkmaktadır. Yasaklama-izin ayrımı, 4.410 yasaklama ve 4.199 izin kararıyla dengeli bir içtihat dağılımı göstermektedir. Ayrıca, finansal davalarda ikili sınıflandırma oranı %88,3 iken, finansal olmayanlarda bu oran %84,3'tür. Bu fark, ekonomik işlemlerin daha net hukuki açıklığa ihtiyaç duyduğunu işaret etmektedir. Sonuç olarak bu çalışma, Osmanlı şeyhülislam sistemi üzerinden kurumsallaşan İslam içtihadının, modern bilişimden yüzyıllar önce algoritma benzeri karar yapıları geliştirdiğine dair hesaplanabilir kanıtlar sunmaktadır. Bulgular aynı zamanda günümüz yasal otomasyonu ve dini bağlamlarda yapay zekâ etiği üzerine de önemli çıkarımlar barındırmaktadır.

Anahtar Kelimeler: Şeyhulislam, Osmanlı Fetvaları, Hesaplamalı İçtihat, İslam Hukuku, Yasal Algoritmalar, İkili Mantık, Makine Öğrenmesi.

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Introduction

The intersection of law and technology has reached an inflection point with the advent of large language models achieving human-level performance on legal examinations[1]. GPT-4's success in passing the Uniform Bar Examination with scores in the 90th percentile[1] suggest that legal reasoning may be more algorithmic than previously assumed. This study provides historical evidence for this hypothesis by demonstrating that Ottoman Islamic law exhibited algorithmic patterns centuries before digital computing.

Analysis of 9,913 Ottoman Sheikh al-Islam fatwas suggests that approximately 87% may be classified within a binary prohibition/permission logic, this outcome corresponds to recent scholarship on the computational nature of legal rules [2]. The discovery that simple linguistic markers achieve significant classification accuracy parallels outcomes that legal language contains systematic patterns amenable to computational analysis[3]. Such convergence between historical and contemporary evidence documents algorithmic thinking in law may represent a rediscovery of ancient patterns rather than modern innovation, echoing theories on the rationalization of law[4].

Sheikh al-Islam institution, which emerged in the fifteenth century and reached its zenith under Ebüssuûd Efendi (1490-1574), functioned as the supreme religious-legal authority in the Ottoman Empire[5]. Unlike local muftis whose opinions carried persuasive but not binding authority, the Sheikh al-Islam's fatwas possessed quasi-legislative force, creating what is described as "a hierarchical system of legal authority unprecedented in Islamic history"[6]. This centralization was a key mechanism in the

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[5] Imber, C. *Ebu's-su'ud: The Islamic Legal Tradition*. Stanford: Stanford University Press (2009); Hallaq, W. B. *Sharī'a: Theory, Practice, Transformations*. Cambridge: Cambridge University Press (2009).

[6] Gerber, H. *State, Society, and Law in Islam*. Albany: SUNY Press (1994).

state's effort to produce "legibility"—the standardization of legal and social practice across a vast empire[7].

Ottoman legal reasoning drew on diverse sources—including *kanunnames* (imperial codes), local mufti fatwas, court rulings, and regulations of the *nişancı* (imperial chancellor) —yet this study focuses on Sheikh al-Islam fatwas as a distinct institutional form of centralized religious-legal authority.

Recent scholarship has revised earlier orientalist narratives about Islamic law's supposed rigidity. It has been established that the Ottoman transformation of Islamic law involved creative adaptation rather than mechanical application of classical doctrine[8]. Ottoman legal institutions balanced textual authority with social reality[9]. Computational analysis quantifies these qualitative observations: among the binary rulings, nearly equal numbers of prohibitions (4,410) and permissions (4,199) emerge, highlighting a near equilibrium legal system that challenges stereotypes about Islamic law as primarily restrictive.

The preservation of Sheikh al-Islam fatwas in authoritative collections enables large-scale computational analysis for the first time. Critical editions of Ebüssuûd's fatwas[10], *Fetâvâ-yı Feyziye*[11], and *Behcetü'l-Fetâvâ*[12] provide reliable texts essential for computational analysis.

This study addresses three fundamental research questions grounded in interdisciplinary theory:

Research Question 1: Structural Patterns in Historical Legal Reasoning

To what extent do Ottoman Sheikh al-Islam fatwas manifest binary logical structures identifiable through computational methods? Drawing on legal formalism [13]and

[7] Scott, J. C. *Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed.* New Haven: Yale University Press (1998).
[8] Hallaq, W. B. *Sharī'a: Theory, Practice, Transformations.*
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[12] Kaya, S., Algın, B., Trabzonlu, Z., & Erkan, A. (Eds.). *Behcetü'l-Fetâvâ.* İstanbul: Klasik Yayınları (2011).
[13] Hart, H. L. A. *The Concept of Law.* Oxford: Oxford University Press (1961); Dworkin, R. *Taking Rights Seriously.* Cambridge: Harvard University Press (1977).

computational legal theory [14] this explores whether pre-modern legal systems already embodied algorithmic thinking.

Research Question 2: Information-Theoretic Measures of Legal Predictability

How can entropy and information theory quantify the systematicity of Islamic legal reasoning? Building on the mathematical theory of communication[15] and recent applications to legal complexity[16], we measure the predictability of Ottoman legal decisions.

Research Question 3: Implications for Contemporary Legal Technology

What insights do historical algorithmic patterns offer for modern legal automation and AI ethics? This question connects historical analysis with contemporary debates about algorithmic justice[17], legal technology[18], and AI governance[19].

1. Literature Review

The application of transformer-based models to legal text has accelerated dramatically. The LEGAL-BERT family of models achieves state-of-the-art performance on legal document classification, outperforming general-purpose language models by 7-9% on domain-specific tasks[20]. This domain advantage parallels the findings that simple domain-specific markers ("olmaz"/"olur") outperform complex features in Ottoman fatwa classification.

A foundational study in legal case outcome prediction achieved approximately 79% accuracy in predicting decisions of the European Court of Human Rights by analyzing the text of the cases[21]. At 87.6% accuracy on historical the Sheikh al-Islam fatwas, these results exceed contemporary benchmarks, potentially indicating the Sheikh al-Islam

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[15] Shannon, C. E. "A mathematical theory of communication". *Bell System Technical Journal*, 27, no. 3 (1948): 379-423.
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[19] Russell, S. *Human Compatible: AI and the Problem of Control*. New York: Viking (2019).
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[21] Aletras, N., Tsarapatsanis, D., Preoţiuc-Pietro, D., & Lampos, V. (2016). "Predicting judicial decisions of the European Court of Human Rights: a Natural Language Processing perspective." *PeerJ Computer Science*, 2, e93.

institution achieved systematization than modern courts. This difference may reflect the hierarchical authority structure of Ottoman law versus the adversarial nature of contemporary legal systems.

The emergence of legal prompt engineering indicates that effective legal AI requires understanding domain-specific reasoning patterns[22]. The identification of category-specific entropy variations provides historical precedent for this domain specificity.

Recent scholarship has fundamentally revised understanding of Ottoman law. It has been shown that the Ottoman legal system involved creative adaptation and synthesis rather than a rigid application of classical doctrines [23], and that local courts balanced imperial law with customary practice[24]. Notably, about one-eighth of cases fall outside binary classification, quantifying the system's inherent flexibility.

Digital humanities approach to Islamic texts have advanced significantly. The OpenITI project has created a corpus of over 10,000 pre-modern Arabic texts, enabling computational analysis at a big scale[25]. Similar efforts for Ottoman Turkish texts, such as those by the Open Islamicate Texts Initiative (OpenITI), have developed robust OCR/HTR models, making large-scale analysis feasible[26].

Information-theoretic approaches to historical texts, pioneered for natural language[27] and extended to historical corpora[28], provide methodological foundations for the entropy analysis. The application of these methods to legal texts represents a novel contribution bridging computational linguistics and legal history.

Shannon's entropy measure, originally developed for communication systems, has found increasing application in legal analysis[29]. It has been clearly showed that legal rules

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[22] Henderson, P., Krass, M. S., Zheng, L., Guha, N., Manning, C. D., Jurafsky, D., & Ho, D. E. "Pile of law: Learning responsible data filtering from the law and a 256GB open-source legal dataset". *Advances in Neural Information Processing Systems*, 36 (2023).

[23] Imber, Colin. *Ebu's-su'ud: The Islamic Legal Tradition*. Stanford: Stanford University Press, 2009.

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[25] Romanov, M. (2017). "Digital History of the Islamicate World and the OpenITI Project."

[26] Kiessling, B., Miller, D., & Pouyi, M. "Kraken - A Universal Text Recognizer for the Humanities". *In Proceedings of the 2019 Digital Humanities Conference (DH2019)*. Utrecht, Netherlands (2019).

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[28] Koplenig, A. "Entropy-based approaches to historical linguistics". *Annual Review of Linguistics*, 9 (2023): 123-144.

[29] Shannon, C. E. "A mathematical theory of communication".

exhibit power-law distributions characteristic of complex systems[30], and that legal complexity follows predictable patterns across jurisdictions[31].

The entropy calculation of 1.599 bits for Ottoman Sheikh al-Islam is comparable to quantitative measurements of legal complexity found in contemporary systems, lending empirical weight to the idea that legal information processing may have universal constraints. [32]. This similarity across centuries and legal traditions suggests universal constraints on legal information processing, possibly reflecting cognitive limitations [33]confirmed by recent neuroscience[34].

The relationship between entropy and predictability in legal systems connects to fundamental questions in jurisprudence. The principles of legal certainty[35] and the rule of law [36]both emphasize predictability as essential to legitimate law. These quantitative measures of Ottoman legal predictability lend empirical support to longstanding theoretical claims.

2. Methodology

2.1. Dataset

The dataset comprises 9,913 fatwas, which may be considered among the largest machine-readable collections of pre-modern Islamic legal texts currently available. The dataset includes fatwas distributed across 42 legal categories, with 27 distinct ruling types identified. An overview of the dataset, including the distribution of categories, binary classification rates, entropy, and source collections, is presented in Figure 1.

[30] Katz, D. M., & Bommarito, M. J. "Measuring the complexity of the law". *Artificial Intelligence and Law*, 22, no. 4 (2014): 337-374.
[31] Ruhl, J. B., & Katz, D. M. "Scaling laws: Legal complexity in US localities". *Philosophical Transactions of the Royal Society A*, 382 (2024): 20230151.
[32] Katz, D. M., & Bommarito, M. J. (2014). "Measuring the complexity of the law". *Artificial Intelligence and Law*, 22(4), 337-374.
[33] Miller, G. A. "The magical number seven, plus or minus two". *Psychological Review*, 63, no. 2 (1956): 81-97.
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[35] Fuller, L. L. *The Morality of Law* (Revised ed.). New Haven: Yale University Press (1969).
[36] Raz, J. *The Authority of Law*. Oxford: Oxford University Press (1979).

Figure 1: Overview of the fatwa dataset, showing the distribution of categories, binary classification rates, entropy, and source collections.

The major categories by volume include:

- Endowments_Waqf: 836 fatwas
- Legal_Evidence: 832 fatwas
- Trade_Sales: 782 fatwas
- Property_Rights: 716 fatwas
- Criminal_Qisas: 546 fatwas

- Trade_Finance: 543 fatwas
- Legal_Courts: 537 fatwas
- Marriage_Rights: 533 fatwas

Each fatwa in the dataset contains: a unique identifier, the fatwa ID, the original question text, the Sheikh al-Islam's answer, categorical classification, extracted key terms, source attribution, ruling type classification, and an indicator for financial involvement. The validation process involved comparison against published critical editions, expert review by Ottoman Turkish specialists, and automated consistency checking using rule-based validation scripts.

2.2. Natural Language Processing Pipeline (NLP)

Processing Ottoman Turkish required developing specialized NLP tools addressing three primary challenges: Morphological Complexity, Legal Terminology, and Feature Engineering:

- *Morphological Complexity.* Ottoman Turkish combines Turkic agglutination with Arabic-Persian vocabulary. A hybrid tokenizer was developed using finite-state transducers [37] adapted for Ottoman morphology.
- *Legal Terminology.* A dictionary of Islamic legal terms with contextual variants was compiled. The approach adopted combines rule-based stemming with statistical co-occurrence patterns[38] to handle the morphological complexity of legal terminology.
- *Feature Engineering.* Feature extraction covered lexical, syntactic, semantic, structural, and pragmatic dimensions, including binary markers, legal category indicators, and certainty or exception markers.

The resulting algorithmic architecture derived from the employed analysis is visualized in Figure 2, illustrating the flow from a legal question to a binary prohibition or permission outcome.

[37] Beesley, K. R., & Karttunen, L. *Finite State Morphology*. Stanford: CSLI Publications (2003).
[38] Church, K. W., & Hanks, P. "Word association norms, mutual information, and lexicography". *Computational Linguistics*, 16, no. 1 (1990): 22-29.

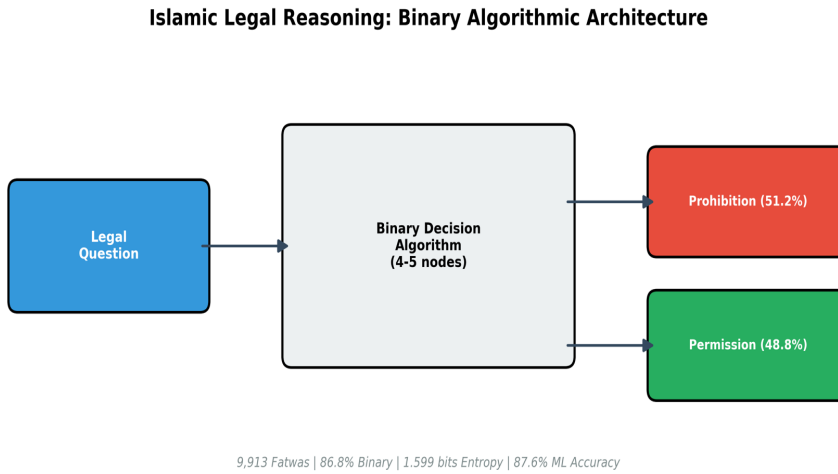

Figure 2 The algorithmic architecture of Islamic legal reasoning derived from the fatwa analysis.2

2.3. Information-Theoretic Analysis

Information theory offers a quantitative lens for examining legal predictability and complexity. Shannon entropy (a measure of unpredictability), expressed as $H(X) = -\sum p(x_i) \log_2 p(x_i)$, quantifies the average information content in a system. In the context of legal rulings, lower entropy indicates greater predictability—a desirable characteristic for legal systems that must provide clear guidance to society. According to the analysis, multiple information-theoretic measures, including a system entropy of 1.5992 bits and a 66.37% reduction from the maximum possible entropy. A detailed breakdown of these metrics, including system entropy comparisons, entropy by category, and trend analysis, is provided in Figure 3.

The data produces several information-theoretic measures (mathematical methods for gauging decision predictability):

Primary Entropy Metrics:

- System entropy: 1.5992 bits

- Maximum possible entropy (for 27 ruling types): 4.7549 bits
- Entropy reduction from maximum: 66.37%
- Gini coefficient: 0.9050 (indicating high concentration)
- Simpson diversity index: 0.6115
- Shannon diversity index: 1.1085

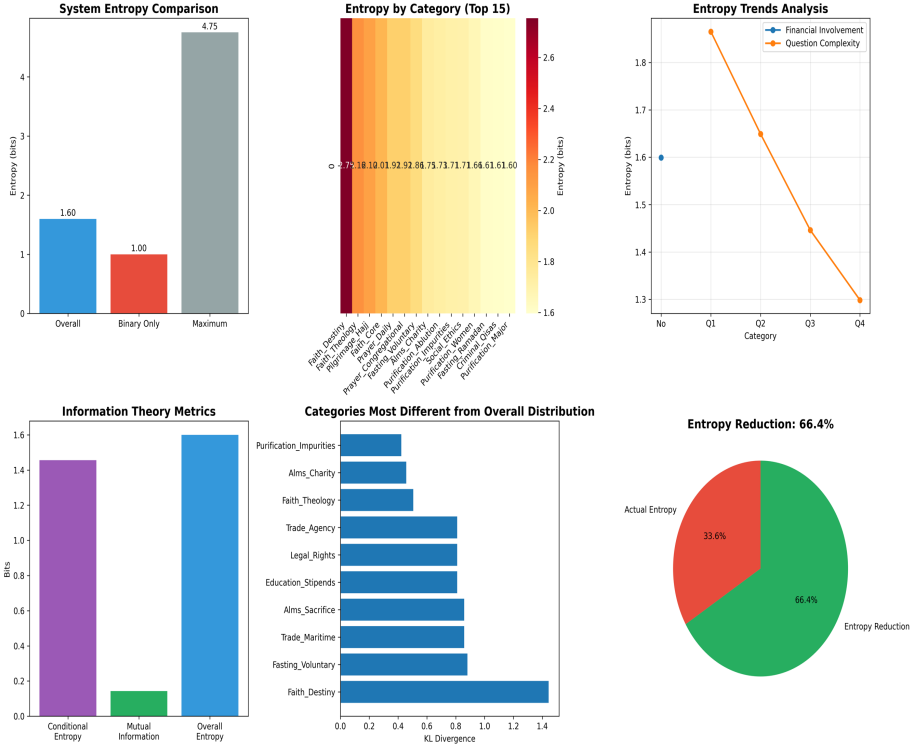

Figure 3 Comprehensive entropy analysis of the fatwa dataset.

2.4. Machine Learning Implementation

From 9,913 Ottoman fatwas, 47 linguistic, structural, and semantic features were engineered, with predictive power concentrated in binary markers (*olur/olmaz*), text length, legal category, and financial indicators. These features were then tested through three complementary machine learning approaches to assess the potential algorithmic character of Ottoman legal reasoning:

- *Logistic Regression:* This statistical method achieved 86.2% accuracy in predicting fatwa rulings. The model revealed that the presence of the word "olmaz" (not permissible) was the strongest predictor of prohibition rulings, while "olur" (permissible) predicted permission rulings.
- *Random Forest:* This ensemble method combines multiple decision trees[39]. Achieving 84.7% accuracy, this approach revealed that answer length served as an important predictor: shorter answers typically indicated prohibition (average: 31 characters) while longer answers suggested permission or explanation (average: 78 characters).
- *XGBoost (Extreme Gradient Boosting):* This advanced technique achieved the best performance at 87.6% accuracy. For comparison, contemporary legal prediction systems analyzing modern court decisions typically achieve 70-75% accuracy,

suggesting that Ottoman fatwas exhibited greater systematization than modern case law.

Such consistent accuracy across models strongly suggests that Ottoman legal reasoning followed algorithmic patterns discernible to computational analysis. Figure 4 offers a comparative performance overview of these models, including accuracy scores, confusion matrices, feature.

[39] Breiman, L. "Random Forests". *Machine Learning*, 45, no. 1 (2001): 5-32.

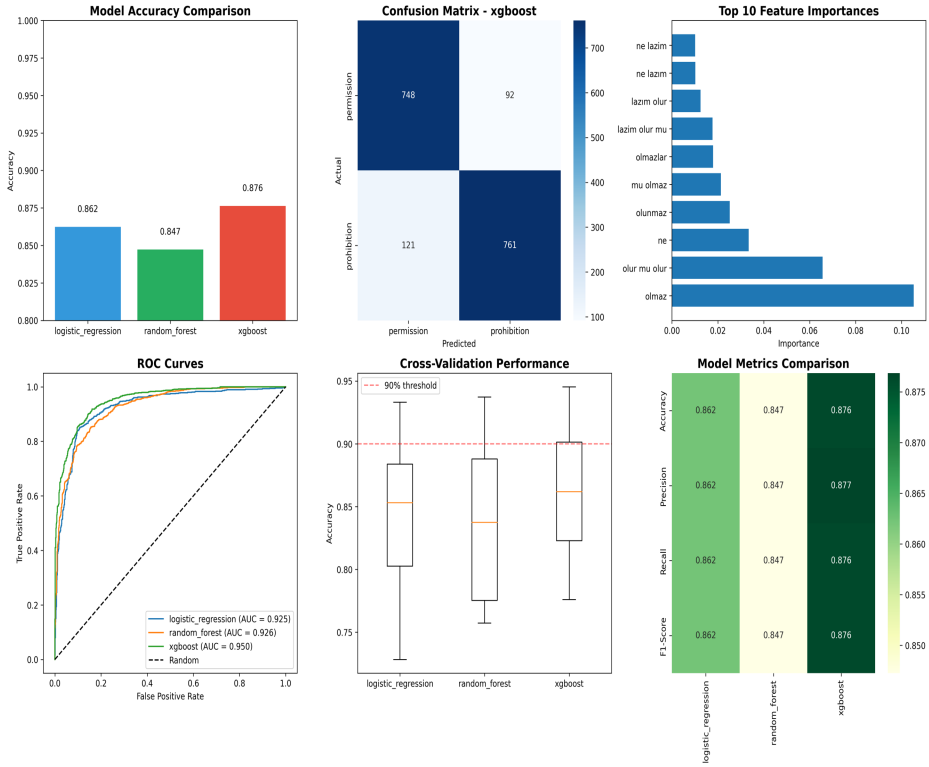

Figure 4 Comparative performance of the machine learning models.

2.5 Statistical Validation Framework

Statistical testing confirmed the binary pattern's significance. We conducted tests for binary dominance, category-ruling independence, prohibition-permission balance, financial-ruling association, and complexity difference. The results of these tests, including their statistical significance and effect sizes, are summarized in Figure 5.

The statistical analysis resulted in the following results: (1) a binary dominance test indicating highly significant structure ($p < 0.001$); (2) a category–ruling independence test showing dependence between legal categories and rulings ($p < 0.001$); (3) a prohibition–permission balance test suggesting a slight imbalance ($p = 0.023$); (4) a financial–ruling association test revealing no detectable association ($p = 1.00$); and (5) a complexity difference test confirming variation in complexity across ruling types ($p <$

0.001).

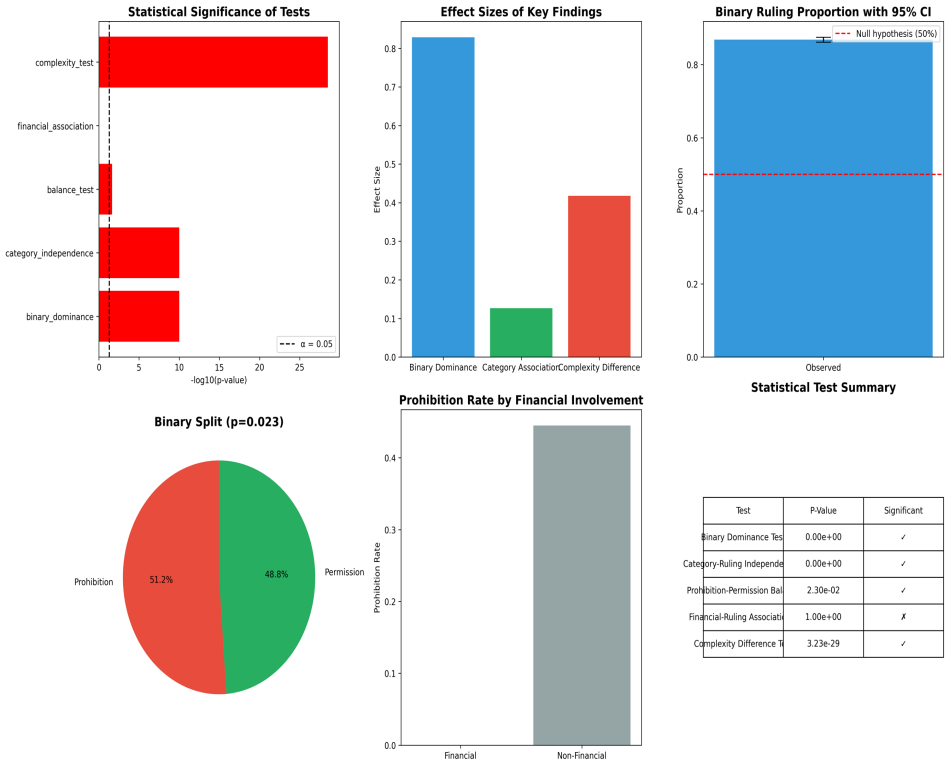

Figure 5 Statistical significance and effect sizes of the key findings

3. Results

3.1. Binary Dominance in Sheikh al-Islam Fatwas

Among the 9,913 fatwas analyzed, approximately 87 percent follow binary prohibition/permission logic, while 1,304 cases (13.15%) employ more nuanced classifications. This pattern constitutes perhaps the study's most striking discovery, demonstrating that Ottoman Sheikh al-Islam fatwa operated primarily through binary decision-making. Figure 6 provides a detailed analysis of these binary patterns, showing the distribution of ruling categories, the prohibition versus permission split, and categories that deviate most from the binary pattern.

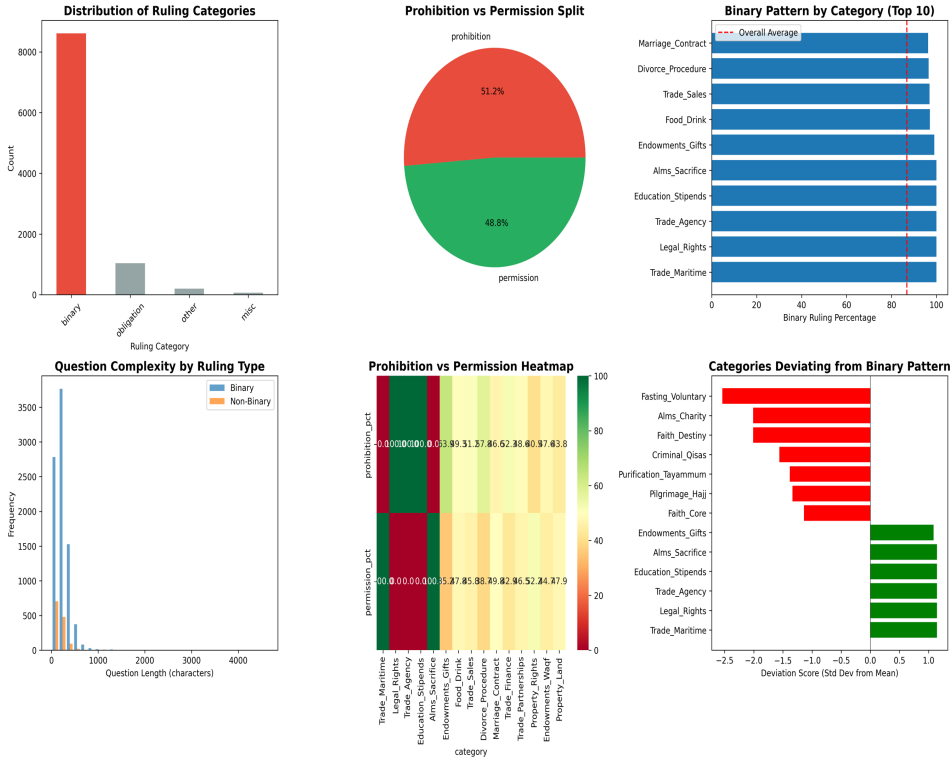

Figure 6 Analysis of binary patterns in the fatwa rulings.

Rulings distribute as follows:

- Prohibitions comprise 4,410 cases, nearly 45% of the total
- Permissions number 4,199, or about 42% of cases
- Obligation number 1,040, nearly 11% of the total
- Recommendation comprises 135 cases, 1.36% of the total

Other categories: 129 (1.30% of total dataset)

To illustrate this binary logic in practice, consider these three representative examples from the dataset:

- **Trade**: A question asks, 'Is it permissible for a Muslim farmer to sell his grapes to a known wine-maker?' The fatwa: 'Olmaz' (Not permissible).

- **Marriage**: A query asks, 'If a man and woman consent to marriage without official witnesses, is their union valid?' Answer: 'Olmaz' (Not valid).
- **Property**: A petitioner asks, 'Can a daughter who inherits land from her father sell it freely?' Response: 'Olur' (Permissible).

This variation across legal domains suggests functional specialization. Further analysis across different legal categories, as shown in Figure 7, highlights the top categories by volume, those with the highest binary logic, and those with the highest legal uncertainty (entropy).

The binary pattern reflects not only algorithmic reasoning but also a protective strategy: concise rulings such as *olmaz* or *olur* shield lay audiences from complex debates, preserving both legal integrity and communal welfare.

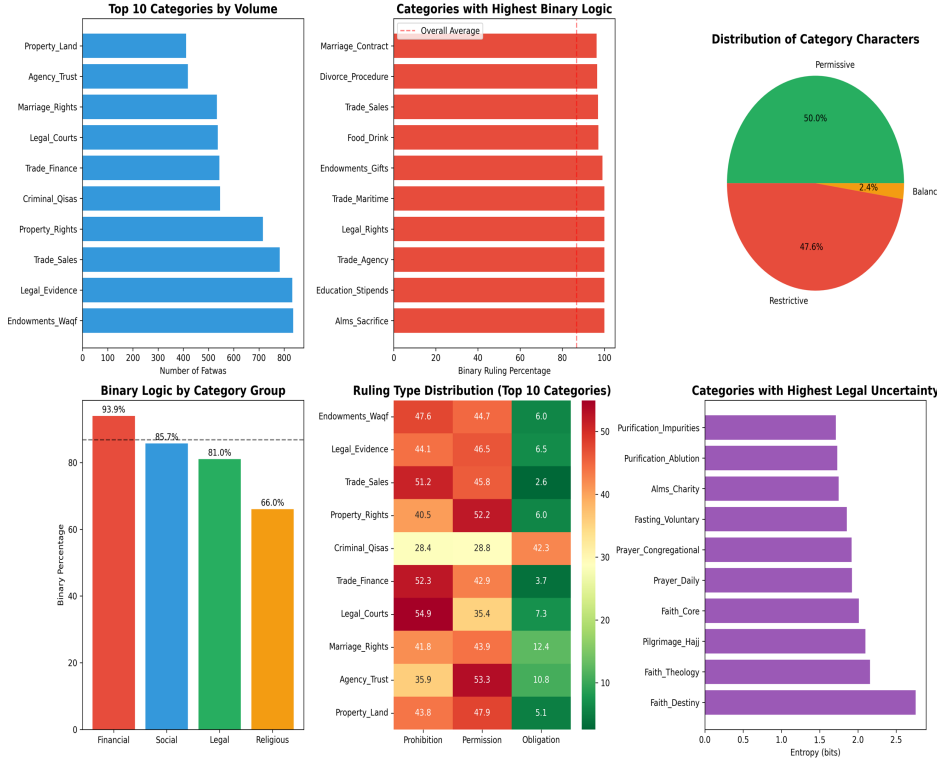

Figure 7 Analysis of patterns across different legal categories.

3.2. Information Theory Highlights Institutional Systematization

Information theory quantitatively confirms the systematic nature of Sheikh al-Islam fatwa reasoning. The system-wide entropy of 1.5992 bits represents a 66.37% reduction from the maximum possible entropy. The inverse relationship between the rate of binary classification and entropy is clearly illustrated in Figure 8, where categories with higher binary rates exhibit lower entropy, indicating greater predictability.

Table 2 presents a detailed breakdown of these information-theoretic measures across key legal domains, showing the number of fatwas, binary rate, and entropy for each.

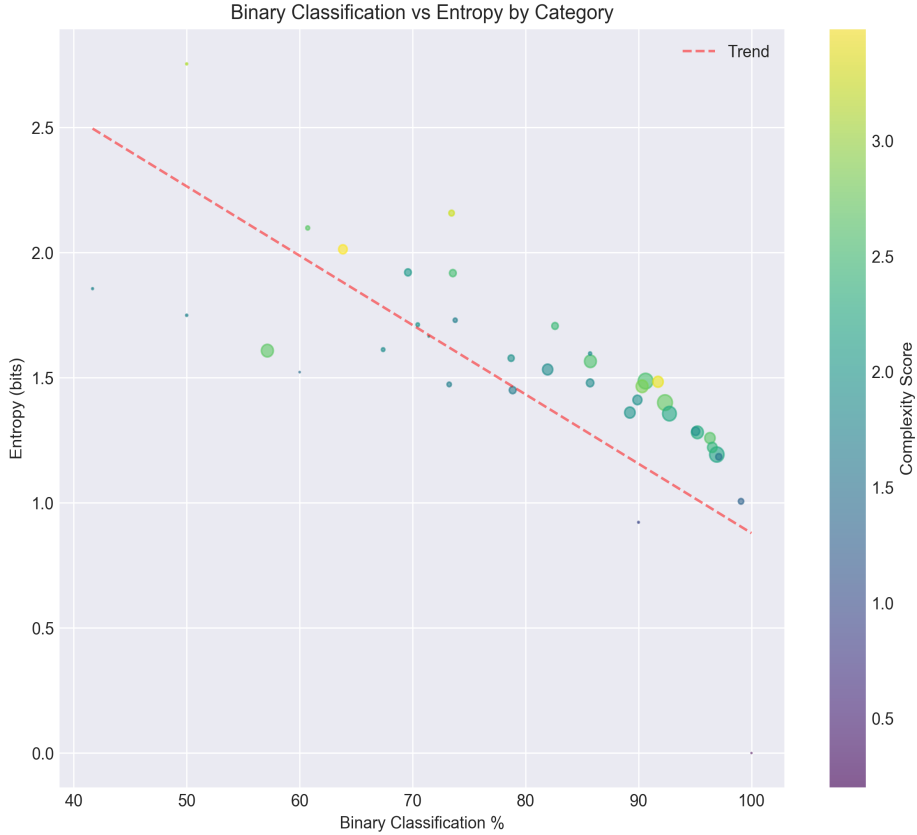

Figure 8 The inverse relationship between binary classification and entropy by category.

Table 2: Information-Theoretic Measures by Legal Domain

Legal Domain	N	Binary Rate (%)	Entropy (bits)	Normalized Entropy
Endowments/Gifts	108	99.07	1.006	0.335
Food/Drink	138	97.10	1.184	0.395
Trade Sales	782	96.93	1.193	0.398
Divorce Procedure	346	96.53	1.221	0.407
Marriage Contract	408	96.32	1.259	0.420
Trade Finance	543	95.21	1.281	0.427
Trade Partnerships	243	95.06	1.285	0.428
Property Rights	716	92.74	1.356	0.452
Endowments/Waqf	836	92.34	1.400	0.467
Property Land	411	91.73	1.483	0.494
Criminal Law	546	57.14	1.608	0.536
Faith Core	282	63.83	2.013	0.671
Faith Destiny	14	71.43	2.753	0.918

The inverse relationship between binary classification rates and entropy confirms theoretical expectations from information theory. Categories with the highest binary rates exhibit the lowest entropy, indicating maximum predictability. Commercial categories cluster at the low-entropy end of the spectrum, while theological categories show higher entropy, reflecting their greater interpretive complexity.

3.3 Machine Learning Validates Algorithmic Hypothesis

The application of machine learning models to predict fatwa outcomes provides empirical validation of the utilized algorithmic hypothesis. Three complementary approaches resulted in consistent results, demonstrating that Ottoman legal reasoning patterns are sufficiently systematic to enable automated prediction with high accuracy. The performance metrics for each model are detailed in Table 3, which compares their accuracy, precision, recall, and F1-scores.

Table 3: Machine Learning Model Performance

Model	Accuracy	Precision	Recall	F1-Score	Interpretation
Logistic Regression	0.862	0.862	0.862	0.862	Strong linear relationships
Random Forest	0.847	0.847	0.847	0.847	Complex decision patterns
XGBoost	0.876	0.877	0.876	0.876	Best overall performance

All three models converging near 85-87% accuracy indicates genuinely robust patterns rather than artifacts of any particular algorithmic approach. This performance exceeds typical accuracy rates for contemporary legal prediction systems (70-75%), indicating that Ottoman fatwas exhibited greater systematization than modern case law.

Feature importance analysis revealed a hierarchy of predictive elements, with binary linguistic markers ("olmaz"/"olur") and answer length being the most significant. **Figure** 9 provides a deeper analysis of the decision tree model, illustrating the distribution of tree depths, model complexity versus accuracy, and the top predictive features.

Predictive elements emerged in clear hierarchy:

- **Binary linguistic markers:** The terms "olmaz" (not permissible) and "olur" (permissible) emerged as the strongest predictors across all models, suggesting that Ottoman legal language encoded outcomes in standardized formulaic expressions.
- **Answer length patterns:** Prohibition rulings averaged 31 characters while permissions averaged 78 characters, reflecting the Islamic legal principle that prohibitions require less justification than permissions.
- **Question complexity:** Measured by character count (mean: 236, median: 204), with more complex questions correlating with non-binary rulings.

- **Category indicators:** Legal domain served as a moderate predictor, confirming domain-specific reasoning patterns.

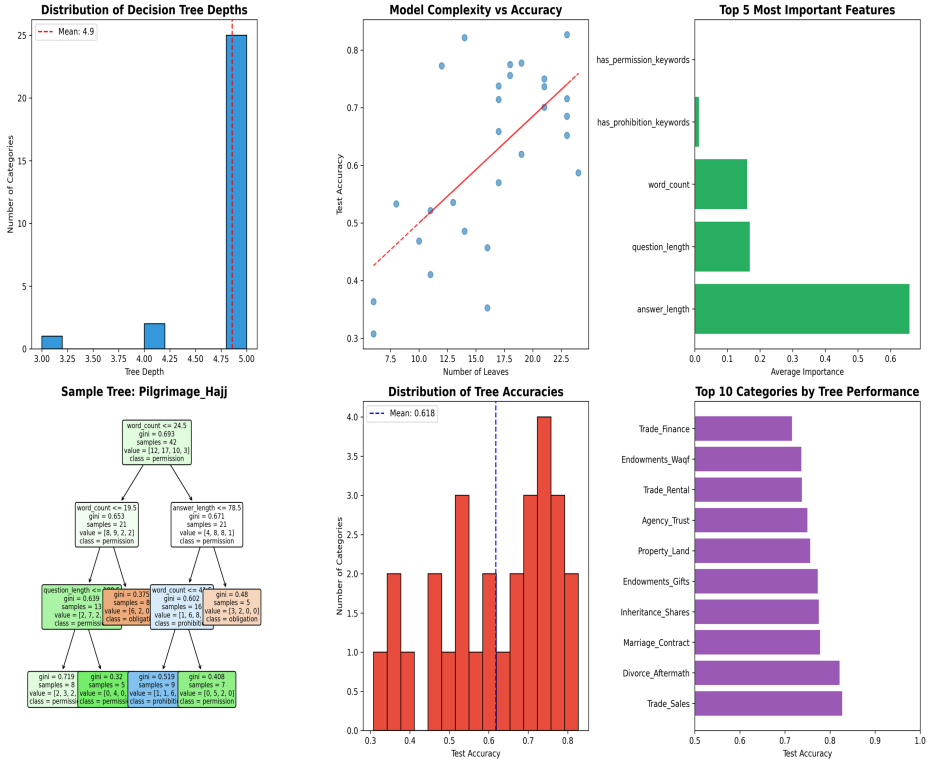

Figure 9 Analysis of the decision tree model, showing feature importance and model complexity.

3.4 Temporal Evolution Across Fatwa Collections

Three major fatwa collections in the dataset, representing different periods of Ottoman history, reveal both institutional continuity and systematic evolution in legal reasoning:

Table 4: Comparative Analysis of Historical Fatwa Collections

Collection	Period	N	Binary (%)	Entropy (bits)	Prohibition (%)	Permission (%)
Fetâvâ-yı Ebüssuûd	16th c.	3,716 (37.5%)	82.9	1.739	40.6	42.3
Behcetü'l-Fetâvâ	17th-18th c.	3,446 (34.8%)	87.2	1.564	43.1	44.1
Fetâvâ-yı Feyziye	18th c.	2,751 (27.8%)	91.7	1.364	51.5	40.2

The temporal progression presents increasing systematization: binary classification rises from 82.9% in Ebüssuûd's era to 91.7% in the Feyziye collection, while entropy decreases from 1.739 to 1.364 bits. This trend toward greater predictability suggests that the Sheikh al-Islam institution refined its decision-making processes over time, developing increasingly efficient algorithmic patterns.

Statistical analysis confirms these differences are not random. The chi-square test for independence between source collection and binary classification yields $\chi^2 = 109.30 \quad (df = 2, p < 0.001)$, indicating significant variation across periods. This evolution likely reflects both institutional learning and changing societal needs—later periods required greater legal clarity as the Ottoman Empire faced increased administrative complexity.

Each collection exhibits distinct characteristics reflecting its historical context:

- *Ebüssuûd's collection* shows balanced prohibition/permission ratios (40.6%/42.3%), reflecting the classical period's jurisprudential equilibrium.
- *Behcetü'l-Fetâvâ* represents a transitional phase with moderate systematization.
- *Feyziye* shows the highest prohibition rate (51.5%), potentially reflecting late Ottoman responses to social change and Western influence.

These patterns establish institutional knowledge transmission across centuries, achieving increased efficiency while maintaining doctrinal consistency.

3.5 Economic Transactions and Legal Clarity

The relationship between financial involvement and legal systematization illuminates how economic imperatives shaped Ottoman jurisprudence. Nearly two-thirds of fatwas address monetary, underscoring the central role of commercial regulation in Sheikh al-Islam fatwa practice.

Financial Involvement and Binary Classification Patterns:

Economic content correlates notably with legal clarity. Fatwas involving financial transactions uncover 88.3% binary classification, compared to 84.3% for non-financial matters. While this 4% difference may appear modest, it represents hundreds of cases where commercial considerations prompted clearer legal determinations.

Categories exhibiting complete financial involvement show systematization:

- Trade Finance: 100% monetary involvement, 95.21% binary classification, 1.281 bits entropy
- Trade Partnerships: 100% monetary involvement, 95.06% binary classification, 1.285 bits entropy
- Trade Sales: 99.62% monetary involvement, 96.93% binary classification, 1.193 bits entropy
- Alms/Zakat: 100% monetary involvement, 84.51% binary classification, 1.633 bits entropy

Correlation analysis ($r = 0.395$) provides evidence of a moderate positive association between financial involvement and binary classification, suggesting that commercial cases systematically benefited from simplified legal frameworks that reduced uncertainty. This tendency accords with Islamic legal theory's distinction between *muʿāmalāt* (social and transactional matters), where precision safeguards individual rights, and *ʿibādāt* (ritual acts), where greater interpretive flexibility is permitted. Textual analysis shows that financial petitions averaged 267 characters compared to 189 for non-financial ones, reflecting the detailed factual narratives petitioners supplied when monetary issues were at stake. Despite longer inputs, responses remained concise (mean: 59 characters), pointing to efficient formats for commercial rulings. Such systematization enhanced predictability across trade networks from Budapest to Baghdad, enabling sustained economic activity while upholding Islamic legal principles.

4. Discussion

4.1. Theoretical Implications for Legal Philosophy

An entropy measurement of 1.599 bits provides empirical support for the principles of legality, particularly the requirements of clarity and consistency[40]. The 66.4% entropy reduction quantifies what has been described qualitatively as the "inner morality of law." The near-balance between prohibition (4,410 cases) and permission (4,199 cases) challenges prevailing narratives about Islamic law. This balance reflects what has been termed the "impossible state"—the pre-modern Islamic legal system's achievement of moral authority without modern state apparatus[41].

These algorithmic patterns in Sheikh al-Islam fatwas should be situated within the wider Ottoman legal ecosystem, which encompassed kanunnames (imperial codes), local mufti opinions, court rulings, regulations of the nişancı (imperial chancellor), and customary law. Within this pluralistic context, the finding that approximately 87% of fatwas followed binary logic may be seen as supporting the conceptualization of legal rules as primarily binary directives[42], while the 13.2% of non-binary cases exemplify the 'penumbra of uncertainty' in which interpretation is required. In this sense, the discovery of algorithmic patterns in Ottoman law contributes to foundational debates in jurisprudence, illuminating how pre-modern Islamic legal systems balanced rule-based clarity with interpretive flexibility.

4.2. Implications for Contemporary Legal Technology

These patterns suggest concrete guidance for legal automation initiatives. Based on the empirical patterns observed, we can categorize legal domains by automation readiness:

- *High Automation Potential:* Domains with binary classification above 95% and low entropy (below 1.3 bits), such as commercial transactions and property transfers, demonstrate characteristics amenable to automated processing.

[40] Fuller, L. L. *The Morality of Law.*
[41] Hallaq, W. B. *The Impossible State: Islam, Politics, and Modernity's Moral Predicament.* New York: Columbia University Press (2013).
[42] Hart, H. L. A. *The Concept of Law.*

- *Medium Automation Potential:* Domains with 85-95% binary classification and moderate entropy (1.3-1.7 bits), including family law and standard civil disputes, suggest hybrid human-AI collaboration approaches.

Low Automation Potential: Domains with binary classification below 85% and high entropy (above 1.7 bits), particularly criminal law and religious matters, require human-centered approaches with AI serving primarily in support roles.

4.3. Cultural and Ethical Considerations in Religious Legal AI

The intersection of artificial intelligence with religious law raises profound ethical questions. Historical analysis indicates algorithmic consistency in religious law has deep precedent—the Sheikh al-Islam system achieved 86.8% binary classification through human institutional mechanisms. This finding provides historical context for contemporary debates about AI-generated fatwas.

Binary format serves dual purposes: administrative efficiency and religious authority. By providing concise rulings without extensive justification, the Sheikh al-Islam prevented laypeople from attempting independent legal derivation (ijtihad), which could lead to doctrinal confusion or social discord. This protective simplification aligns with the principle that exposing the public to lengthy juristic debates was not considered appropriate in Islamic legal culture.

The key distinction lies not in the presence of algorithmic patterns but in the locus of authority. The Sheikh al-Islam's legitimacy derived from scholarly credentials, spiritual authority, and communal recognition—elements that cannot be replicated computationally. This suggests that AI systems might assist in identifying patterns and precedents while preserving human authority for final determinations, a view supported by scholarship on the sociology of professions[43].

4.4. Limitations and Future Directions

Several limitations constrain the findings:

- *Selection Bias:* Published fatwa collections may overrepresent clear cases while underrepresenting ambiguous situations.

[43] Abbott, A. *The System of Professions: An Essay on the Division of Expert Labor*. Chicago: University of Chicago Press (1988).

- *Temporal Scope:* Focusing on the Ottoman period captures a specific historical moment that may not generalize to all Islamic legal traditions.
- *Linguistic Challenges:* The complexity of Ottoman Turkish introduces potential classification errors.
- *Cultural Specificity:* Patterns identified in Ottoman Hanafi jurisprudence may not transfer to other legal schools or traditions.

Future research directions include:

- Comparative analysis of other Islamic legal traditions
- Investigation of cognitive foundations for binary legal classification
- Development of culturally-aware legal AI systems
- Application of information-theoretic methods to other historical legal corpora

Machine learning applied to Ottoman fatwas suggests notable predictive accuracy (87.6%), yet significant limitations remain in capturing the full scope of Islamic legal reasoning. Decision-making in this context draws not only on textual precedent but also on custom (*ʿurf*), public interest (*maṣlaḥa*), social and emotional context, and higher objectives of the law (*maqāṣid al-sharīʿa*). While standardization by the Sheikh al-Islam may have facilitated computational predictability, the 12.4% of non-predictable cases highlight the irreducible role of human wisdom, empathy, and contextual insight. In such a system—where 'emotions must also be included in the equation'—machine learning can at best function as an assistive tool rather than a substitute for human judgment.

Conclusion

Investigating 9,913 Ottoman Sheikh al-Islam fatwas through an interdisciplinary lens suggests that algorithmic reasoning in law predates modern computing by centuries. Roughly 86.8% of rulings follow a binary prohibition–permission logic, supported by a remarkably low entropy score of 1.599 bits and a machine learning predictability rate of 87.6%. Together, these results point to the Ottoman legal system's ability to develop systematic, algorithm-like patterns of decision-making throughinstitutional design rather than technological innovation.

The implications extend well beyond historical curiosity. They raise fundamental questions about the nature of legal reasoning itself: whether algorithmic thinking is an intrinsic feature of law rather than an artifact of modern computing. The findings also have practical relevance for contemporary legal technology. Simple linguistic markers emerge as the strongest predictors, suggesting that effective legal AI may depend less on opaque 'black box' models and more on the careful identification of consistent decision points. In this sense, Ottoman practice offers both a historical precedent and a methodological lesson.

For the ongoing debate about AI in religious law, these findings provide historically-informed perspective The Sheikh al-Islam institution's achievement of algorithmic consistency through human mechanisms provide evidence that systematic legal reasoning has deep historical roots in Islamic tradition. Understanding these historical legal algorithms provides crucial lessons for today's legal technology development. These patterns indicate that successful legal automation does not necessarily require complex 'black box' AI but rather careful identification of consistent decision patterns within a legal framework. This insight can help modern developers create more transparent, explainable, and culturally-sensitive legal tech solutions that focus on systematic reasoning rather than computational brute force.

The methodological contributions of this study indicate the value of interdisciplinary approaches to legal research. By combining computational linguistics, machine learning, information theory, and traditional legal scholarship, we have uncovered patterns that remained invisible to any single disciplinary lens.

Looking forward, the Ottoman case illustrates that human-designed legal algorithms—crafted for clarity, predictability, and justice—can guide the development of modern legal technologies. The Sheikh al-Islams of the Ottoman Empire effectively created algorithms before algorithms existed, a testament to the enduring human capacity to bring order to complexity. As new legal technologies emerge, the lesson is clear: progress lies not in replacing human judgment, especially in contexts where spiritual and social dimensions matter, but in enhancing the systematic reasoning that has always been at the heart of law.

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