Evidence-Based Machine Learning Algorithm Selection for Construction Data Analytics: A Systematic Review

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Research Problem

The Challenge:

> **ML applications in construction lack structured decision-making frameworks for algorithm selection**

- Construction projects generate massive*, diverse datasets*
- Traditional analysis methods are insufficient
- No systematic approach to match algorithms with dataset characteristics
- Current practice: trial-and-error approach

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Research Objectives

What We Investigated?

Primary Question:

Is evidence-based guidance being used to select ML algorithms in construction research?

We Analyzed:

- ✓ Frequency of ML algorithm usage
- ✓ Model objectives (prediction vs. classification)
- ✓ Reasoning behind algorithm selection
- ✓ Correlations with dataset characteristics

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Methodology

Systematic Literature Review (PRISMA)

Data Sources:

- Web of Science
- IEEE Xplore
- ICONDA
- ScienceDirect
- ASCE

450	70	30	115
Initial Articles	After Screening	Final Articles	ML Methods

Search: "machine learning" AND "construction industry"

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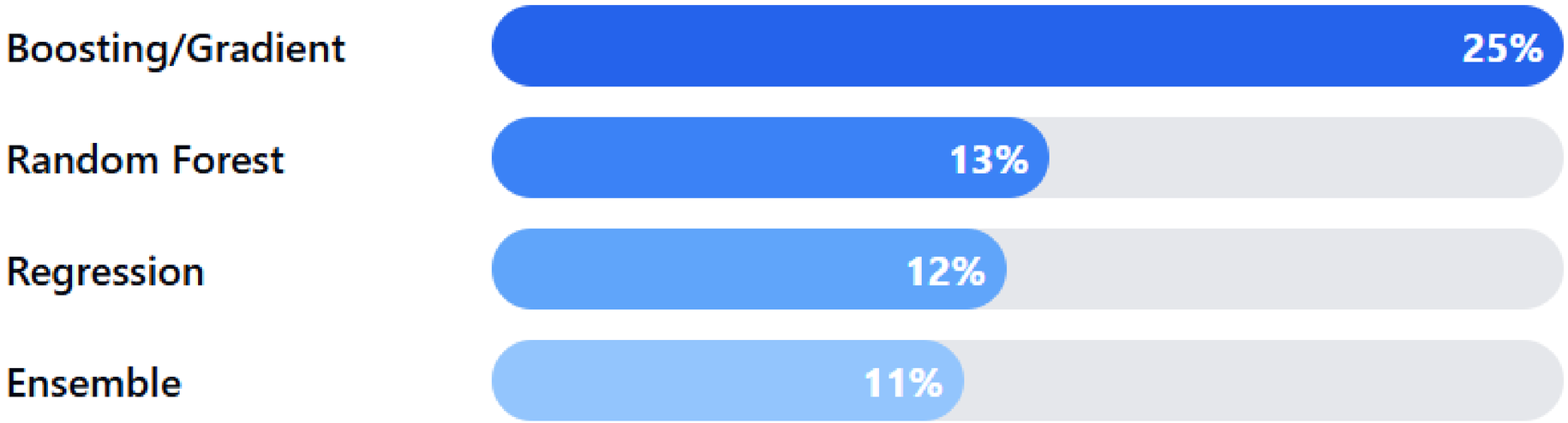
KEY FINDINGS

1. Algorithm Frequency

Most Frequently Used ML Algorithms



Key Insight:

Advanced ensemble methods dominate, suggesting construction datasets require sophisticated algorithms to handle complexity.

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KEY FINDINGS

2. Algorithm by Analysis Objective

Prediction Models (55.7%)

1. Regression	**73%**
2. ANN	**62%**
3. Boosting/Gradient	**54%**

Classification Models (44.3%)

1. KNN	**67%**
2. Decision Tree	**58%**
3. SVM	**56%**

Note: Some algorithms like Random Forest and Ensemble show versatility across both objectives.

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KEY FINDINGS

3. Selection Reasoning

Why Researchers Choose Algorithms

Past use for similar data	23%
Better accuracy	17%
Past use for similar objective	16%
NO REASON provided	16%
Literature review	15%

No systematic methodology!

CRITICAL FINDING:
39% rely on precedent alone (past use) - not systematic analysis
16% provide NO justification whatsoever

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The Problem Illustrated

Current Selection Approach

❌ Current Practice

- Trial-and-error testing
- Following precedent
- "It worked before"
- No systematic rationale
- Time-consuming
- May miss optimal solutions

✓ Needed Approach

- Evidence-based selection
- Data-driven decisions
- Match algorithm to data characteristics
- Consider analysis objectives
- Efficient selection process
- Optimal performance

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The Problem Illustrated

3. Current Selection Approach

The Gap:
Researchers intuitively recognize algorithm-data relationships but lack a systematic framework to guide their decisions.

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Algorithm Characteristics Summary

Boosting/Gradient ⭐

+ High accuracy, handles non-linear data, reduces overfitting
- Complex, computationally intensive

Random Forest

+ Robust, versatile, reduces overfitting
- Scalability issues with large datasets

Regression

+ Simple, interpretable, fast
- Assumes linear relationships, limited with complex data

ANN

+ Handles complex patterns, high accuracy
- "Black box", prone to overfitting

KNN

+ Simple, captures local patterns
- Poor with high-dimensional or imbalanced data

Decision Tree

+ Easy to interpret, handles mixed data types
- Prone to overfitting, sensitive to noise

Full details available in paper Table 1 and Section 4.1

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Implication for Construction

Why This Matters?

For Researchers:

✓ Save time in algorithm selection
✓ Improve model performance
✓ Justify methodological choices
✓ Avoid trial-and-error approaches

For Industry Practitioners:

✓ Better prediction of costs, schedules, safety
✓ More reliable risk assessments
✓ Evidence-based decision making
✓ Efficient use of data analytics resources

For the Field:

✓ Standardization of ML practices
✓ Foundation for best practices
✓ Improved reproducibility

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Recommendation for Future Research

What Next?

1. Selection Matrix Development

Create evidence-based norms mapping algorithms to dataset characteristics and objectives

2. Quadrant Framework

Categorize algorithms as traditional/regular/advanced based on complexity and timeline

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Recommendation for Future Research

What Next?

3. Cross-Industry Analysis

Compare with retail, manufacturing, finance to identify algorithmic versatility

4. Empirical Validation

Test algorithm-dataset-objective combinations to validate optimal performance

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Conclusions

Key Takeaways

Main Findings:

✓ Analyzed 115 ML methods from 30 construction studies

✓ Boosting/gradient methods most common (25%)

✓ Clear patterns by objective (Regression for prediction, KNN for classification)

✓ 39% rely on precedent, 16% provide no justification

Confirmed Gap:

No systematic selection approach exists that maps algorithms to dataset characteristics and analysis objectives

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Thank you!

Questions?

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Acknowledgements

- Name - Affiliation
- Name - Affiliation
- ETC.

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Thank you

For any quesitions, please contact

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