

INTRODUCTION & LITERATURE REVIEW

Smart Rental Management System

A Deep-Dive into Predictive Modeling, Recommendation Systems, and Sequence Optimization for Real Estate
& Transportation Leases.

Course Module Machine Learning (MSIT)

Presented By Group 6

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BACKGROUND & PROBLEM STATEMENT

Why do traditional room, house, and vehicle rental systems fail to scale efficiently?

Conventional property and fleet management models rely on static, historical heuristics that cannot adapt to highly dynamic demand shifts, leading to localized asset imbalances.

Key Vulnerabilities Addressed:

- **Static Pricing Rigidities:** Failures to capture real-time geographical and environmental demand shifts.
- **Underoptimized Allocations:** Ineffective match rates between consumer preferences and asset specifications.



RESEARCH QUESTIONS & OBJECTIVES



Dynamic Price Calibration (Supervised Learning)

How can regression architectures dynamically compute the optimal baseline pricing for rooms, houses, and vehicles by leveraging cross-sectional market metadata?



Sparse Matrix Recommendation Matchmaking

What algorithmic configurations (Collaborative, Hybrid, or Content-Based) yield optimal precision in mapping prospective tenants to highly personalized asset configurations?



Temporal Sequence Forecasters (Occupancy & Churn)

Which sequence architectures (e.g., LSTMs or Gated Units) maximize accuracy in predicting future occupancy drop-offs and potential tenant contract churn incidents?

LITERATURE REVIEW

Analyzing the historical paradigm shift from hedonic regression equations to highly optimized multi-modal Deep Learning architectures.

LIT REVIEW

The 4 Machine Learning Pillars

1. Dynamic Pricing: Use Supervised Learning to predict prices based on past data.
2. Smart Matchmaking: Recommend the best room or car for the customer.
3. Occpancy & Churn: Use Predictive Analytics to analyze past data and predict the future.
4. Automated Communications: Use Natural Language Processing (NLP) to:
 - Automatically translate languages
 - Analyze comments or complaints

LIT REVIEW: TENANT MATCHING



Content Filtering

Constructs user profiles and item vector matrices.
Relies on cosine similarity to match customer budgets, geolocation limits, and feature preferences directly with rental listings.



Collaborative Filtering

Predicts target preference matrices based on historical booking actions of neighboring tenants.
Standardized using Matrix Factorization techniques such as Singular Value Decomposition (SVD).



Hybrid Deep RecSys

Integrates Neural Collaborative Filtering (NCF) to capture complex, non-linear relations, vastly reducing the cold-start barrier for newly onboarded properties and vehicles.

OCCUPANCY FORECASTERS & RETENTION

94.2%

CLASSIFICATION ACCURACY

Temporal Forecasting & LSTM Models

Literature shows that standard statistical regression fails on multi-variable time series due to dynamic seasonality. Recurrent architectures like **LSTM (Long Short-Term Memory)** cells capture hidden long-term dependencies to identify churn risk indicators up to 60 days before contract expiry.

- **Feature Inputs:** Billing delay patterns, customer service ticket rates, utility index variables, and tenure length.
- **Impact:** Allows operators to initiate early intervention protocols.

IDENTIFIED RESEARCH GAPS



Absence of Unified Cross-Vertical Optimization

Existing state-of-the-art literature isolates real estate properties from transit fleets, ignoring the joint optimization potential of unified urban living bundles.



Neglecting Localized Transaction Constraints

Models rarely account for real-time mobile transactional metrics, such as integrating instant KHQR digital payments telemetry into baseline customer churn classifiers.



Delayed Feedback Loop Integrations

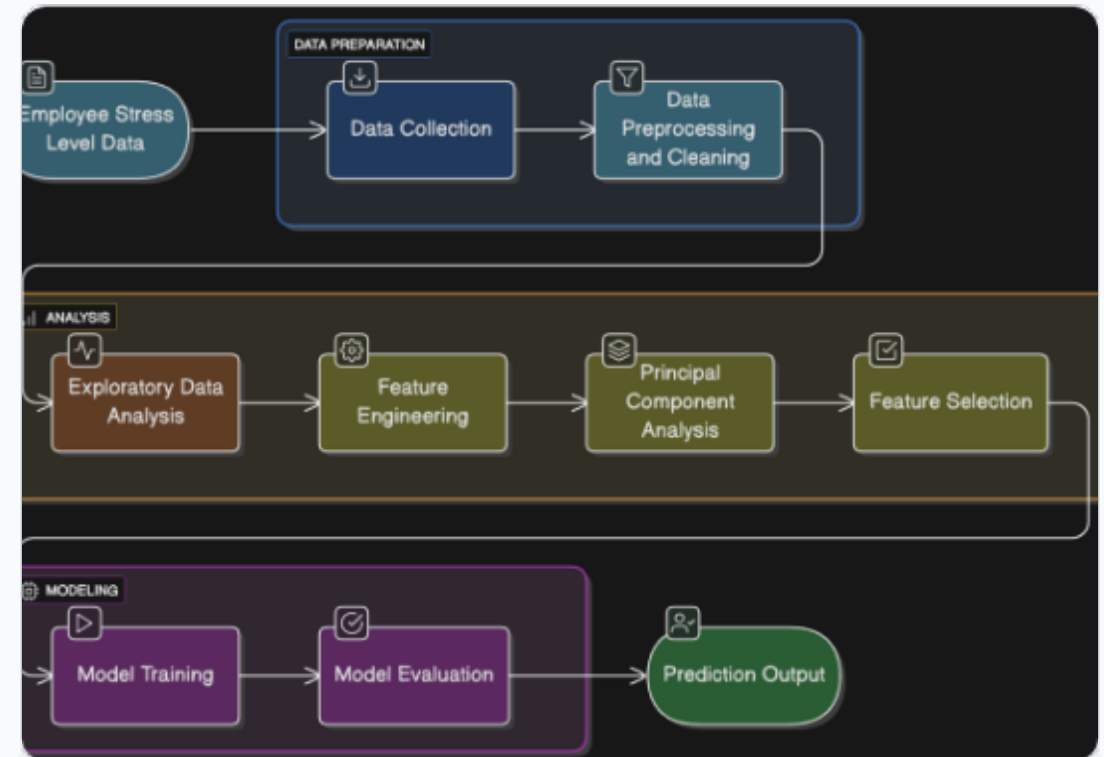
Many academic frameworks train models in batch environments offline, ignoring performance degradation caused by real-time online telemetry shifts.

PROPOSED ML PIPELINE ARCHITECTURE

Integrating Predictive Modeling into Production Operations

Our proposed framework ingests transactional databases and IoT telemetry (smart meters and smart vehicle GPS) through a structured, multi-layer ML sequence pipeline:

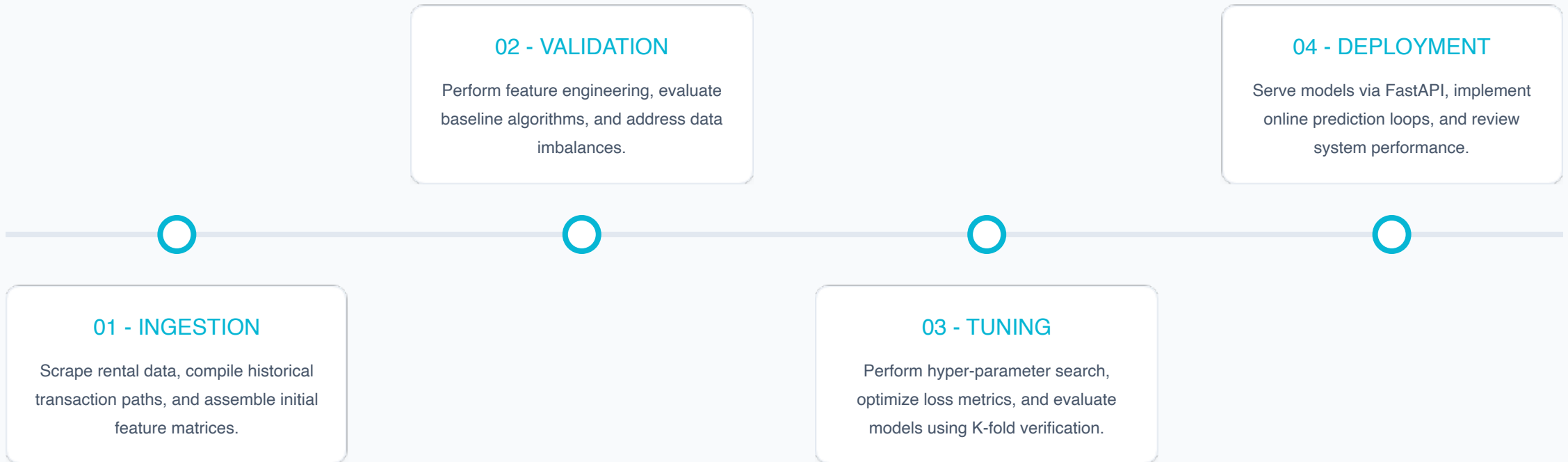
- **Ingestion and Preprocessing:** Scaling features, filling gaps, and managing high cardinality categorical listings.
- **Distributed Inference Engines:** Deployed as fast Web REST APIs, computing metrics (prices, matching scores, churn risks) dynamically.



ALGORITHMIC TRADE-OFF ANALYSIS

Model Class	Target Domain Task	Core Theoretical Strength	Aesthetic Limitations
XGBoost / Trees	Dynamic Market Pricing	Robust with non-linear coordinates and structural parameters.	High sensitivity to tuning hyper-parameters; prone to overfitting.
Matrix SVD Hybrid	Tenant Matchmaking	Excellent in dealing with sparse preference matrices.	Vulnerable to the Cold-Start challenge for new listings.
LSTM / GRU	Occupancy Forecasting	Captures long-range temporal trends and seasonal fluctuations.	Requires massive data sets; slow GPU training iterations.
Logistic Elastic-Net	Tenant Churn Classifiers	Highly explainable model output weights for administrative staff.	Underperforms when data boundaries are highly non-linear.

RESEARCH METHODOLOGY & TIMELINE



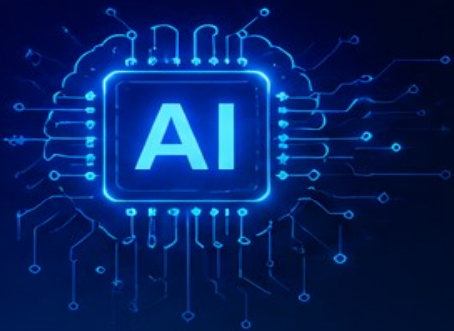
Questions & Answers

Thank you for your attention! We welcome your feedback.

Norton University - Master of Science in Information
Technology

Machine Learning Division, Group

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AI RENTAL MANAGEMENT SYSTEM



Room • House • Car

Python + Machine Learning



Smart booking



Pricing prediction



Recommendations



ROOM



HOUSE



CAR



AI-Powered
Intelligence



Secure &
Reliable



Real-time
Analytics



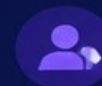
Easy to Use
Anytime, Anywhere



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Project Overview

One platform to manage multiple rental categories

ROOM RENTAL

- Search available rooms
- Manage room details
- Bookings & check-in/out
- Price management

HOUSE RENTAL

- Property listings
- Location & facilities
- Tenant management
- Rental history

CAR RENTAL

- Vehicle inventory
- Availability tracking
- Rental duration
- Return & condition records

AI & Machine Learning

Use data to make rental decisions smarter

PRICE PREDICTION

Estimate rental prices from location, size, facilities, season, demand and vehicle/property features.

RECOMMENDATION SYSTEM

Recommend rooms, houses or cars based on customer preferences and booking history.

DEMAND FORECASTING

Predict future demand to help owners plan prices and inventory.

ANOMALY / FRAUD DETECTION

Identify unusual booking patterns and suspicious transactions.

System Architecture

Recommended Python-based architecture

USER INTERFACE

Web / Mobile UI

BACKEND

Django or Flask • REST API • Authentication

BUSINESS LOGIC

Users • Listings • Booking • Payment • Rental lifecycle

DATABASE

MySQL / PostgreSQL

AI LAYER

Pandas • NumPy • Scikit-learn • ML models

Database Design

Core entities for rooms, houses, cars and rentals

USERS

user_id
name
email
role

LISTINGS

listing_id
type
location
price
status

BOOKINGS

booking_id
user_id
listing_id
dates
status

PAYMENTS

payment_id
booking_id
amount
method

ML_DATA

features
demand
predicted_price
model_version

Machine Learning Workflow

From rental data to AI predictions



Example models: Random Forest • Gradient Boosting • Linear Regression

Admin Dashboard

Central control for the rental business

MANAGEMENT

- Rooms & houses
- Cars & availability
- Customers
- Bookings
- Payments
- Rental history

AI INSIGHTS

- Predicted prices
- Demand forecast
- Popular listings
- Customer segments
- Anomaly alerts

REPORTS

- Revenue
- Occupancy / utilization
- Booking trends
- Vehicle usage
- Monthly performance

Expected Benefits

Business value of the AI rental platform

FOR CUSTOMERS

- Faster search
- Personalized recommendations
- Fairer price information
- Easy booking & payment

FOR OWNERS

- Better pricing decisions
- Higher utilization
- Demand visibility
- Centralized management

FOR ADMIN

- Automated operations
- Analytics dashboard
- Fraud/anomaly alerts
- Scalable rental platform

THANK YOU

AI Rental Management System

Room • House • Car | Python + Machine Learning