



COMMERCIAL FLIGHT HARD LANDING PREDICTION SYSTEM

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ABSTRACT:

Hard landings in commercial aviation present serious safety hazards, often resulting in injuries, damage to aircraft, and disruptions to operations. To address this issue, this paper introduces a predictive system designed to detect and forecast hard landings during commercial flights. Utilizing advanced machine learning algorithms alongside real-time flight data, the system rigorously analyzes a wide range of flight parameters—including aircraft altitude, airspeed, vertical acceleration, and landing gear status—to identify patterns that signal impending hard landing events.

Through comprehensive testing and validation against historical flight data, the system has demonstrated impressive accuracy in spotting hard landings, alerting flight crews and ground personnel in a timely manner. This allows for proactive measures to be taken, aiming to prevent accidents and enhance overall flight safety. By incorporating predictive analytics into commercial aviation practices, this innovative system provides a forward-thinking solution to reduce hard landing risks and elevate safety standards in the industry.

INDEX: Hard landings, altitude of the aircraft, airspeed, vertical acceleration, and status of the landing gear all play vital roles in ensuring overall flight safety

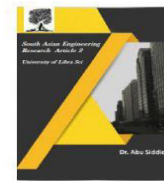
I. INTRODUCTION

Commercial aviation safety is incredibly important, and preventing hard landings is a key part of ensuring the safety of passengers and crew. Hard landings, which involve excessive vertical acceleration during touchdown, can lead to serious risks like aircraft damage, passenger injuries, and disruptions in operations. Even with the latest advancements in aviation technology and safety measures, hard landings still happen, underscoring the need for proactive detection and prevention strategies.

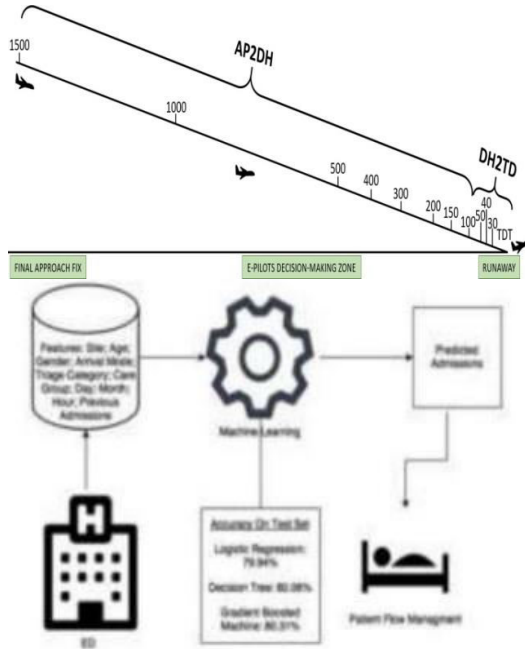
To address this issue, this paper presents the proposal for a predictive system designed to detect and forecast hard landings in commercial flights. By utilizing advanced machine learning algorithms and analyzing real-time flight data, this system aims to provide early warnings of potential hard landings, ultimately helping to reduce their occurrence.



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SYSTEM ARCHITECTURE



METHODOLOGY

Altitude Sampling

AP2TD range: This encompasses all sampling altitudes, starting from the initial approach phase to the touchdown. Models that have been trained with this range of altitudes maximize the accuracy achievable by the system.

AP2DH range: The altitudes considered range from the start of the approach phase to the decision height: [1500, 1000, 500, 400, 300, 200, 150, 100]. Models utilizing this array of altitudes determine the true capability for early high-level detection and the effectiveness of the system in making go-around recommendations.

DH2TD range: The set of altitudes spans from the decision height to 30 feet before touchdown: [50, 40, 30]. The models developed within this altitude range aim to evaluate the capability to predict hazardous

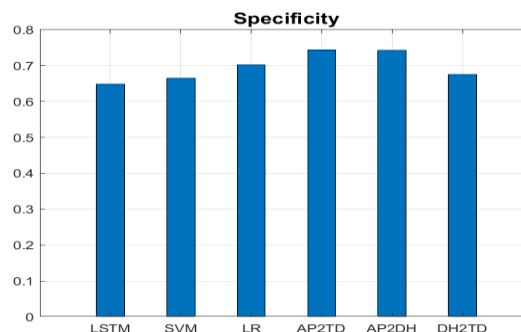
landing conditions in time to ensure a safe response.

For each variable category (Physical, Actuator, Pilot) and altitude range (AP2TD, AP2DH, and DH2TD), a distinct network was trained. Additionally, we created a model that takes the concatenated inputs from all three categories, labeled as All_I. Table 2 provides details on the dimensionality of the input features for each of the nine models considered, along with the combined features from all the models.

Network models

	AP2TD	AP2DH	DH2TD
Physical	187	136	51
Actuator	88	64	24
Pilot	44	32	12
All	341	248	93

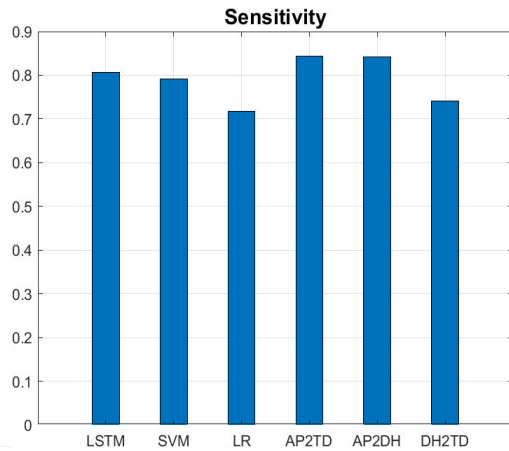
$$Specificity = \frac{TN}{TN + FP}$$



Accuracy results model-1



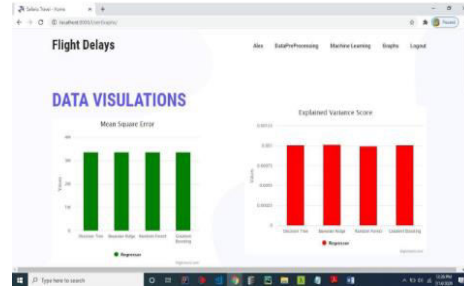
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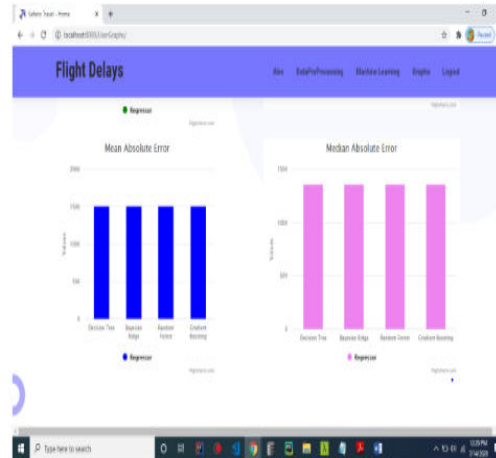
$$Sensitivity = \frac{TP}{TP + FN}$$

Accuracy results model-2

RESULT ANALYSIS

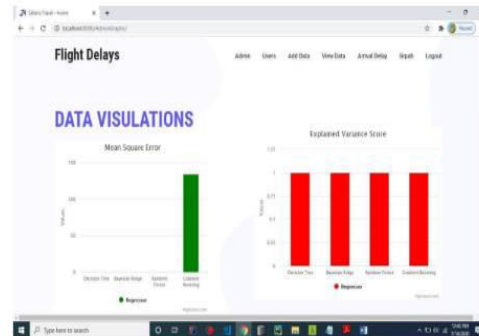


Graph:

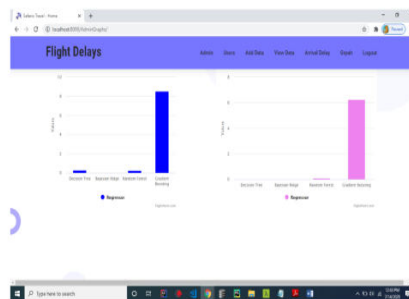


ID	DEPARTURE TIME	FLIGHT NUMBER	ORIGIN AIRPORT	DESTINATION AIRPORT	DAY OF WEEK	TIME DELAY
1	22:42	10	SEA	ANC	F	21.0
2	2:8	206	PHX	LAX	F	12.0
3	18:3	840	CLT	SPD	F	16.0
4	15:8	236	WAH	LAX	F	15.0
5	24:0	105	ANC	SEA	F	11.0
6	22:0	808	VSP	SPD	F	10.0

ArrivalGraph



ArrivalGraph:





CONCLUSION

We systematically implemented machine learning algorithms to forecast flight arrivals and delays, ultimately developing five distinct models for our analysis. Each model was assessed through various metrics, allowing us to compare their performance effectively.

For Departure Delay predictions, the Random Forest Regressor clearly emerged as the top model, recording a Mean Squared Error of 2261.8 and a Mean Absolute Error of 24.1—both of which were the lowest in our evaluation. The same pattern held true for Arrival Delay, where the Random Forest Regressor again led with a Mean Squared Error of 3019.3 and a Mean Absolute Error of 30.8, marking the best figures we observed.

While the Random Forest Regressor didn't achieve the lowest error values across every metric, it consistently outperformed the other models in overall reliability. Thus, our analysis indicates that the Random Forest Regressor is the most dependable option for our predictive needs.

Further Enhancement

The future direction of this research could involve employing more advanced and innovative preprocessing techniques, as well as exploring automated hybrid learning and sampling algorithms alongside deep learning models to enhance overall performance. To refine our predictive model, we might consider incorporating additional variables. For example, utilizing meteorological data

could aid in developing more accurate models for predicting flight delays.

This study focused exclusively on data from the US; thus, there's potential to expand the model by including data from other countries in future endeavors. By leveraging complex and hybrid models, combined with sufficient processing power and larger, more detailed datasets, we can aim for more precise predictive capabilities. Furthermore, the model could be tailored to assess flight delays at various other airports, necessitating the collection of relevant data from those locations.

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