Early Classification of Landing Quality Using Time-Series Flight Data and Gradient Boosting

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***Abstract*—This paper presents a machine learning approach for early classification of aircraft landings as either good or bad, using time-series data from onboard flight logs. We explore feature extraction techniques from GPS altitude, derived descent rate, and indicated airspeed, and train a gradient boosting classifier using a curated set of manually labeled flight approaches. The model demonstrates strong accuracy when full approach data is used, and is further evaluated under constraints where only partial approach data is available. Results suggest early indicators of landing quality exist, though bad landings become more apparent closer to touchdown.**

***Index Terms*—Aviation safety, machine learning, gradient boosting, landing prediction, time-series classification**

I. Introduction

Safe and stable aircraft landings are a critical component of aviation safety. This work investigates whether the quality of a landing can be predicted using a time-series of sensor values recorded during approach. Specifically, we train a machine learning model to classify landings as "good" or "bad" using data collected from general aviation aircraft.

II. Methodology

A. Data Collection

Flight logs were obtained from a series of general aviation approaches at KPRC airport. Each log contains a CSV file with time-series data including GPS altitude (AltGPS), vertical speed (VSpd), and indicated airspeed (IAS). The final 60 seconds of each approach were extracted, and each approach was manually labeled as good or bad using custom visual inspection tools.

B. Preprocessing and Feature Engineering

For each approach, the following features were computed:

- AltGPS (raw altitude samples)
- Altitude Rate: first derivative of AltGPS (ft/min)
- IAS (when applicable)

The result is a 1D feature vector of fixed size per approach.

C. Model Training

We used `XGBClassifier` from the `xgboost` library [1]. Hyperparameters included 100 estimators and max depth of 5. Models were evaluated using 5-fold cross-validation. Performance was also measured on an 80/20 train/test split for reporting confusion matrices and classification scores.

III. Results

Using all 60 seconds of data:

- Accuracy: 97.5%
- Bad landing recall: 94%
- Good landing precision: 99%

Using only the first 40 seconds of data:

- Accuracy: 83.5%
- Bad landing recall: 23%
- Good landing recall: 95%

Adding IAS had minimal effect on early classification.

IV. Discussion

The model is highly effective at identifying good landings early in the approach. However, bad landings are much harder to detect until the final seconds, which is consistent with human pilot judgment. Feature engineering beyond basic altitude metrics may be necessary to improve early recall of bad landings.

V. Conclusion

This work demonstrates that landing quality prediction is feasible using time-series data from flight logs. A gradient boosting classifier trained on altitude-derived features achieves strong accuracy when the full approach is used. Predicting landing quality early remains challenging, especially for bad landings, and presents opportunities for future feature development.

References

[1] T. Chen and C. Guestrin, "Xgboost: A scalable tree boosting system," *Proceedings of the 22nd ACM SIGKDD international conference on knowledge discovery and data mining*, pp. 785–794, 2016.