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Anomaly detection via a Gaussian Mixture Model for flight operation and safety monitoring

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Abstract-

Safety is key to civil aviation. To further improve its already respectable safety records, the airline industry is transitioning towards a proactive approach which anticipates and mitigates risks before incidents occur. This approach requires continuous monitoring and analysis of flight operations; however, modern aircraft systems have become increasingly complex to a degree that traditional analytical methods have reached their limits - the current methods in use can only detect ‘hazardous’ behaviors on a pre-defined list; they will miss important risks that are unlisted or unknown. This paper presents a novel approach to apply data mining in flight data analysis allowing airline safety experts to identify latent risks from daily operations without specifying what to look for in advance. In this approach, we apply a Gaussian Mixture Model (GMM) based clustering to digital flight data in order to detect flights with unusual data patterns. These flights may indicate an increased level of risks under the assumption that normal flights share common patterns, while anomalies do not. Safety experts can then review these flights in detail to identify risks, if any. Compared with other data-driven methods to monitor flight operations, this approach, referred to as ClusterAD-DataSample, can (1) better establish the norm by automatically recognizing multiple typical patterns of flight operations, and (2) pinpoint which part of a detected flight is abnormal. Evaluation of ClusterAD-DataSample was performed on two sets of A320 flight data of real-world airline operations; results showed that ClusterAD-DataSample was able to detect abnormal flights with elevated risks, which make it a promising tool for airline operators to identify early signs of safety degradation even if the criteria are unknown a priori.

Index Terms- Flight safety; Flight data; Flight operations monitoring; Anomaly detection; Cluster analysis

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