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Motor speed estimation and failure detection of a small UAV using density of maxima

Key words: Unmanned aerial vehicle (UAV); Speed identification; Failure detection; Chaos

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Motivation

1. There have been advancements in unmanned aerial vehicle (UAV) applications and commercialization in regulation worldwide and in studies about safety and critical applications.
2. Unexpected failures in brushless direct current (BLDC) motors can be catastrophic, causing financial and human losses.
3. Fast and efficient solutions are necessary, demanding less computing effort.

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Main idea

1. Detect anomalous behaviors quantifying the chaos using density of maxima.
2. Even small perturbations are detected and the motor speed can also be estimated.
3. The technique is called signal analysis based on chaos using density of maxima (SAC-DM).
4. It is necessary to count only the number of peaks in the signals from an accelerometer.

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Method

1. The density of maxima approach is based on cyclic equilibrium behavior.
2. The SAC-DM technique computes the density of maxima to estimate the correlation coefficient.
3. In periodic and chaotic systems, the density of peaks (maxima) reflects the chaotic behavior.

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Major results

Speed detection

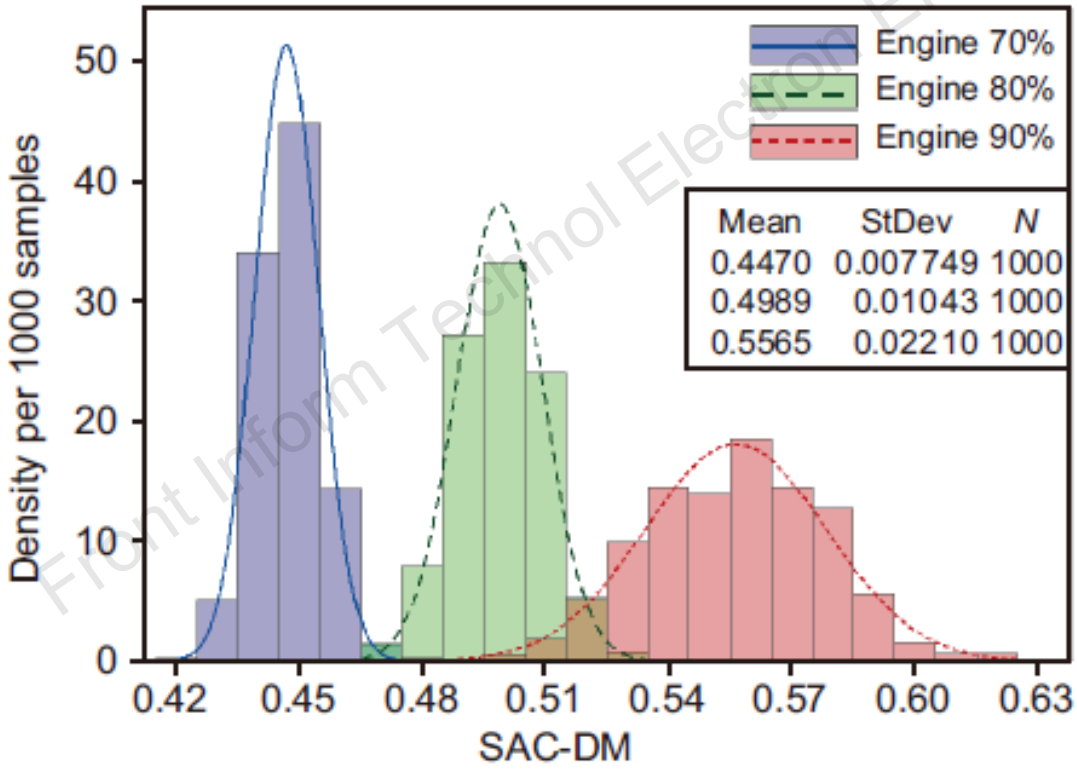

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Fig. 6 Histogram of SAC-DM calculated from the acceleration vector signal for 70%, 80%, and 90% speeds

Major results (Cont'd)

Failure detection

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Table 4 Accuracy in the failure detection considering SAC-DM from the Z axis, grouped by change in the propeller and in the gravitation center

Propeller	Accuracy		Average
	GC-OK	GC-bad	
OK	78.4%	33.1%	**55.75%**
One tape	87.6%	100%	**93.80%**
Two tapes	99.1%	98.3%	**98.70%**
Average	**88.37%**	**77.13%**	**82.75%**

The results in bold represent the average accuracy for each line and column

Conclusions

1. The result proves the possibility of applying the presented technique to estimate the speed of the motor using a computationally simple approach, counting only the density of peaks in the time domain, without any filtering.

2. Accuracies of 82.75% on average and 100% in the best case were achieved for the tests with a small UAV, which demonstrates the efficiency of the proposed method.

3. The algorithm used to detect failure is based only on testing whether a value is in a fixed range or not.

4. Only one second was enough to achieve the successful accuracy of 82.75%.

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Prof. Alisson V. BRITO received his PhD degree in electrical engineering from the Federal University of Campina Grande (UFCG), Brazil, in the field of microelectronics in 2008, with cooperation with the Karlsruhe Institute of Technology (KIT), Germany. He has experience in computer science, with emphasis on design and development of embedded systems. He is currently a professor at Universidade Federal da Paraiba (UFPB) and a coordinator of the Laboratory of Embedded Systems and Robotics (LASER).

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