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AUTOMATED SYSTEM FOR PREDICTIVE EXPRESS DIAGNOSTICS OF QUADCOPTER UAV MOTORS. DRONE DIAGNOSTICS IN FIELD CONDITIONS

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Modern operation of unmanned aerial vehicles (UAVs) in field conditions requires new approaches to technical maintenance. Sudden failure of the propulsion system leads to the loss of the aircraft; therefore, the transition to a Predictive Maintenance strategy is critical. Traditional vibration diagnostic methods require motor disassembly and the use of laboratory vibration stands, which takes about one hour per aircraft and is completely impossible in field conditions.

In this work, an innovative methodology for non-destructive (in-situ) express diagnostics is proposed, which transforms the drone itself into a measuring complex (laboratory stand) by utilizing built-in precision MEMS gyroscopes and the Blackbox flight data logging system. The 'DronExpert' automated system has been developed, using the integrated MEMS gyroscopes as vibration sensors. The scientific novelty lies in the development of a data collection algorithm using the standard motor reverse rotation mode ('Turtle Mode') without propellers. This allows for selective motor activation and the acquisition of isolated vibration signatures without dismantling the motors.

The developed 'DronExpert' autonomous cross-platform complex automates the entire cycle of telemetry data processing. The system calculates the Root Mean Square (RMS) vibration value to detect static or dynamic imbalance and the Crest Factor (peak factor) for early predictive detection of impact pulses from rolling bearing micro-defects. Furthermore, using Fast Fourier Transform (FFT), the program performs spectral analysis with an innovative adaptive dynamic range contrasting algorithm, enabling the visualization of weak diagnostic features against a background of high electromagnetic noise.

The final stage of the work was the development of the Human-Machine Interface (HMI) for the "DronExpert" system. The dashboard does not merely display data; it functions as an intelligent decision support system. The central element of the report is the Motor Condition Diagnostic Map, implemented using the "traffic light" classification principle:

Green Sector (Stable): motor condition is within normal limits.

Yellow Sector (Warning): scheduled maintenance is recommended.

Red Sector (Critical): presence of pronounced deviations in monitored indicators. Risk of shaft failure or bearing disintegration. Operation is prohibited.

The software automatically integrates FFT spectrogram plots for each motor, allowing the engineer to verify the system's automated verdict. Results are exported to a PDF file, which serves as a 'technical passport' for the aircraft's pre-flight check.Experimental validation on full-scale 10-inch UAVs with 3115 motors (900 KV) confirmed the accuracy of the algorithms previously modeled in the **MATLAB** environment. The software complex successfully identifies non-linear shaft deformations by recording energy transformation into a powerful second harmonic (2X) under critical loads.

In conclusion, the implementation of this expert-type automated system allows for the reduction of the total diagnostic time for a single UAV to 3 minutes, completely eliminating the human factor by generating a PDF report with a traffic light classification of the motors' technical condition.