

- detecting, as a function of the abnormality score z_i , at least one abnormal flight, in which, for each abnormal flight detected, a phantom flight the nearest to the abnormal flight detected is determined while being in the zone of normal flights.

Embodiments of the invention are advantageously completed by the following characteristics, taken singly or in any technically possible combination thereof:

- ~~for each abnormal flight detected, a phantom flight the nearest to the abnormal flight detected is determined while being in the zone of normal flights.~~
- the parameters of the abnormal flight detected are compared with those of the phantom flight determined in order to detect at least one parameter of the abnormal flight that has rendered abnormal said abnormal flight detected.
- the Gaussian entropy component analysis comprises the following sub-steps:
 - o determination of a matrix of similarity K of size $N \times N$, the components of which quantify the proximity between two flight signatures X_i ;
 - o breakdown into eigen vectors of the matrix of similarity K to obtain N eigen vectors $a_1, \dots, a_N$ and N eigen values $\lambda_1, \dots, \lambda_N$ such that $\forall i=1, \dots, N \quad K \cdot a_i = \lambda_i \cdot a_i$;
 - o determination, for each eigen vector, of its entropy coefficient γ_i

selection of a sub-assembly of eigen vectors $\{a_m\}_{m \in \{1, \dots, N\}}$ such that the sum of the entropies γ_m is greater than the percentage of the sum of the N entropies γ_i .

CLAIMS

1. Method of analysing flight data recorded during N flights of at least one aircraft, by means of a flight data recorder of an aircraft, the data being grouped together by flight i in a signature vector of the flight X_i of size d , the components of which correspond to data recorded during said flight i of the aircraft, a flight i being thus defined by the signature vector X_i , the method comprising the following steps:

- Gaussian kernel entropy component analysis of the flight signatures X_i , to obtain a zone of normal flights and classifying the flight signatures X_i with respect to their distance to said zone;
- determining, for each flight i , an abnormality score z_i defined by the distance of a flight signature X_i with respect to the zone of normal flights;
- detecting, as a function of the abnormality score z_i , at least one abnormal flight.

~~2. Analysis method according to claim 1, in which, for each abnormal flight detected, a phantom flight the nearest to the abnormal flight detected is determined while being in the zone of normal flights.~~

~~3. Analysis method according to claim 2, in which the parameters of the abnormal flight detected are~~

compared with those of the phantom flight determined in order to detect at least one parameter of the abnormal flight which has rendered abnormal said abnormal flight detected.

43. Analysis method according to claim 1, in which the Gaussian entropy component analysis comprises the following sub-steps:

- determination of a matrix of similarity K of size $N \times N$, the components of which quantify the proximity between two flight signatures X_i ;
- breakdown into eigen vectors of the matrix of similarity K to obtain N eigen vectors $a_1, \dots, a_N$ and N eigen values $\lambda_1, \dots, \lambda_N$ such that $\forall i=1, \dots, N \quad K \cdot a_i = \lambda_i \cdot a_i$;
- determination for each eigen vector of its entropy coefficient γ_i ;
- selection of a sub-assembly of eigen vectors $\{a_m\}_{m \in \{1, \dots, N\}}$ such that the sum of the entropies γ_m is greater than the percentage of the sum of the N entropies γ_i .

54. Analysis method according to claim 43, in which the

entropy coefficient is defined by $\forall i=1, \dots, N \quad \gamma_i = \frac{\lambda_i \cdot \left(\sum_{j=1}^N a_{i,j} \right)}{N^2}$.

65. Analysis method according to one of claims 4-3 to 5-4 in which the abnormality score of a flight i is defined by:

$$z_i = 1 - \sum_{k \in m} \frac{(K_i^T a_k)^2}{\lambda_k}.$$

76. Analysis method according to one of claims 4-3 to 65, in which the components of the matrix of similarity K are defined by:

$$\forall i=1, \dots, N \quad K_{i,j} = \exp\left(-\frac{\|X_i - X_j\|^2}{2\sigma^2}\right),$$

where σ^2 is a predetermined bandwidth parameter.

87. Analysis method according to the preceding claim, in which the bandwidth parameter σ^2 is determined in the following manner:

- a matrix D of size $N \times N$ corresponding to the distance between two flights is determined and is defined in the following

manner $\forall i=1, \dots, N \quad D_{i,j} = \|X_i - X_j\|^2$;

- each component of each column is arranged in ascending order to obtain a matrix D' ;

- k first lines of the matrix D' thereby obtained are selected and the others are eliminated to obtain a matrix D' of size $k \times N$;

- the average of each column of the matrix D' to obtain N values $y_1, \dots, y_N$ is determined;

- the median absolute deviation of the values $y_1, \dots, y_N$ defined by $\text{mad} = \text{mediane}\{|y_i - \text{med}|\}$ with $\text{med} = \text{mediane}\{y_1, \dots, y_N\}$ is determined;

- the bandwidth parameter σ^2 is determined from the median absolute deviation of the values $y_1, \dots, y_N$ by the following functional $\sigma^2 = \max_{y_i < \text{med} + 20 \cdot \text{mad}} \{y_i\}$.

98. Analysis method according to one of the preceding claims, in which the data of a flight i are grouped together in a matrix F_i of dimension $T \times P$ with T the number of data recorded during the flight i and P the number of parameters recorded, the vector X_i having for components the columns of the matrix F_i end to end, the vector X_i being then of dimension $d = T \times P$ and is defined by

$$X_i = [F_i(t=1, p=1), \dots, F_i(t=T, p=1), \dots, F_i(t=1, p=P), \dots, F_i(t=T, p=P)].$$

99. Analysis method according to one of claims 1 to 87, in which the data of a flight i are grouped together in a matrix F_i of dimension $T \times P$ with T the number of data recorded during the flight i and P the number of parameters recorded, the vector X_i having for components the columns of the matrix F_i sampled to select $n < T$ recordings $t'_1, \dots, t'_n$ of parameters, the vector X_i being then of dimension $d = n \times P$ and is defined by

$$X_i = [F_i(t=t'_1, p=1), \dots, F_i(t=t'_n, p=1), \dots, F_i(t=t'_1, p=P), \dots, F_i(t=t'_n, p=P)].$$

100. Analysis method according to one of claims 1 to 87, in which the data of a flight i are grouped together in a matrix F_i of dimension $T \times P$ with T the number of data recorded during the flight i and P the number of