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INTELLIGENT SYSTEM FOR ADAPTIVE PILOT PERFORMANCE ASSESSMENT

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***Abstract**: This paper will present an entirely new developed intelligent system for high precision adaptive assessments of aircraft piloting abilities. Integrated optimization components for these abilities provide the base in decision-making process concerning the pilots' hierarchy and admittance in flight training specific programs. The system is built as a complex and parametric set of tools, with hierarchical set of specific flying stimulus, weighted in the pilot's performances, acting as base of assessment process. The subjects fly in virtual environment, where receive specific visual, sound and tactile information, in a cockpit specific form. A set of basic and generic tasks is developed for building more complex scenarios, focusing on a stimulus category at one time (visual, flight, navigation, environment integration). Also, a multi-stream data acquisition system (data integration in simulated flight, physiological data and behavior data) is implemented. Data in the intelligent system is stored in relational structured databases: basic scenario database, complex scenario database, subjects' database, results database.*

***Keywords**: flight simulators, pilot assessment, intelligent systems, aviation*

1. GENERALITIES

The main goal of the intelligent system is to allow high precision assessments of aircraft piloting abilities, by integrating optimization components and aiming to provide the base in decision making process concerning the pilots' and navigating candidates' hierarchy and their admittance in flight training specific programs. This system is built as a complex and parametric set of tools, used for the assessment of pilots' flying capabilities in different training stages during the flying school, and for the assessment of pilot candidates' flying potential. It will assist the specialized staff in the decisional processes of pilots' selection. The base of assessment process is a hierarchical set of specific flying stimulus. For generating this hierarchy the stimulus type is weighted in the pilot's performances. The environment where the subject will fly is a simulated one, where the subject will receive specific visual, sound and tactile information, in a cockpit specific form. For this, a set of basic and generic tasks are developed on which the more complex scenarios can be built; different flight simulations are also built based on the considered stimulus hierarchies, focusing on a stimulus category at one time (visual, flight, navigation, environment integration). All these are supported by a simulation system for the virtual environment, a flight simulation system, a multi-stream data acquisition system (data integration in simulated flight, physiological data, behavior data) and a processing, structuring, correlative

analysis of all the information and decision making system. The Intelligent System functions in a network infrastructure which includes the server (the examiner workplace), a set of computers where the subjects will perform and a physiological and behavior data acquisition and processing equipment. The data from the Intelligent System is stored in a global relational database structured by content in specific sub bases: basic scenario, complex scenario, subjects and results.

2. SYSTEM CAPABILITIES REFLECTED IN ASSESSMENT SESSION

The subject assessment session implements a stage structure: subject identification; subject accommodation with session requirements; subject's theoretical training stage; subject's theoretical knowledge assessment; simulator controls training stage; main simulation stage; optimization stage; data processing; decision stage.

The Intelligent System capabilities: building the specific flying stimulus set; building the stimulus hierarchy; weighting the stimulus types in flying performances; building the different flight simulations based on the current stimulus hierarchies; building the flying tasks set, so that the most important psychical processes involved to be covered; the simulation's scenarios manipulation; the relevant parameters set elaboration for flying capacity optimization; building the relevant psycho-physiological set of parameters (EEG, EKG, FC, pressure on the controls, brain signals, visual focus, pulse, blood pressure, local temperature, local resistance – see Fig.1) which best describes the tested subjects general panel; working with complex models for the acquired data, aiming to minimize the dimension of information universe without losing content.

The main challenges approached during developing the system: creating the generic flight simulator, with a specific interface; the functional integration of the intelligent system; generating of investigation, simulation, data processing and optimization procedures; elaborating the decision procedures; elaborating database manipulation procedures.

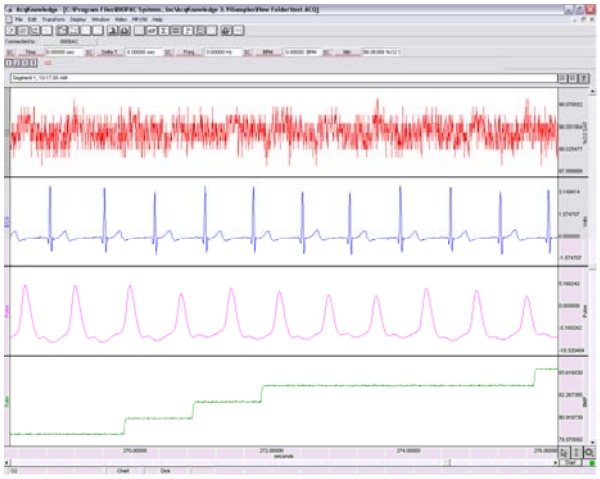

Fig. 1: Physiological stream interface

3. DATA PROCESSING INSIDE INTELLIGENT SYSTEM

The intelligent system provides a genuine set of knowledge regarding the human factor performances quantification, mainly his behavior in the act of flight. Also, it builds dimension reduction models of the information field acquired in assessment sessions, with data loss minimization, respectively with the extraction of that information that has a major impact in previsions elaboration and performances hierarchies setting. Furthermore, it contributes to drawing the separation line between the flight school and aviation specialized programs admitted personnel and the rejected one. The feedback and post assessment analyze procedures implemented provide knowledge regarding aircraft piloting technique ability optimization.

The acquired data processing models are statistic, presuming a minimum and maximum distribution analyses, an average data analyses, respectively kurtosis and skewness, which will be applied at specific deviations level to each candidate, deviations acquired in the simulated flight process, under the real trajectory deviations form of the imposed specific mission trajectory. In analyzing the candidate behavior related to the statistical group to whom he belongs, specific box-plot representation analyses are performed. Also, three-dimensional viewing models of the real and imposed trajectories are implemented, on

mission assembly and primary components (flight type: horizontal, in climbing-descent, turning, takeoff – landing), with the possibility to dynamically modify the observer's position related to the trajectory – see Fig.2. In addition, the deviations in focus will be displayed, too. The statistic analyzing models are applied also to all candidate controls (stick, rudder and throttle). The acquired information are related to the results of the theoretical knowledge exam which is taken during the assessment session time. Overall, the resulting information is related to the specialty knowledge obtained through other methods from the flight personnel, active or in different school training stages and aviation programs.

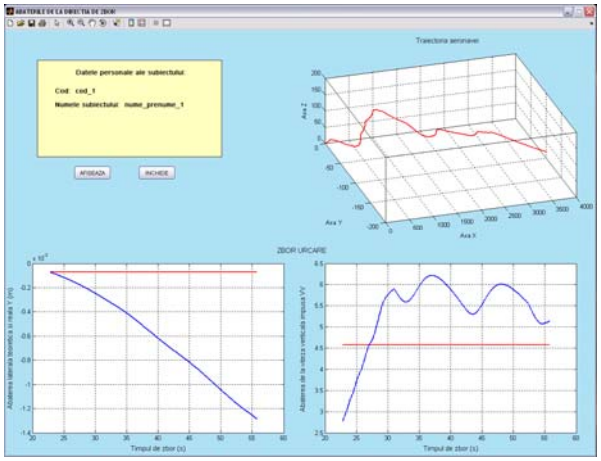

Fig. 2: Post flight flying data stream analysis

The Intelligent System comes with a series of novelties:

- The assessment session complexity: the subject runs through a series of stages: database registration and the coherence and identity checking; virtual environment training through the simulated cockpit construction; theoretical knowledge exam; training on the simulator; virtual environment and simulated flight; acquired data volume (real flight, simulated flight, commands, training and exams results, physiological profile); dimensional reduction models for acquired data volume, keeping only the data with an impact on the assessment, prediction and optimization; candidate control behavior analyze and optimization;
- Board instruments and cockpit database are dynamic; theoretical tests database is dynamic;
- The Scenarios Generator and the included scenarios database permit, practically, the use of an unlimited number of flight scenarios;
- Inclusion of data analyzing models and physiological data sets;
- Acquired data statistic analyze models generation: extreme values, average values, kurtosis, skewness on the candidate distribution data, respectively box-plot model analyze for candidate position analyze related to the significant group to which he belongs, positioning him on a part or another of a marker (for example admitted, rejected) ;
- Post assessment analyze models generation, with three-dimensional graphic (dynamic position of the observer), at a whole flight mission level, at a primitive trajectory section level, respectively with deviations graphic analyze and box-plot representation technique.

The implementation of Intelligent System requires two sides dynamically integrated, regarding the acquisition of valid results, sustained by real investigations, on pilots or flight school candidates, on who's basis the subject's profile estimation can be made, regarding their abilities in flying an aircraft, taking into account the subject's complete panel: physical, physiological and of simulated environment integration. The first implications appear in the performance optimization at candidate group level, and at selected pilot

level, simultaneous with the costs minimization bound on the flying personnel training. The multiple side integration problem – the simulation technology, the adaptation of the simulated environment to the flying specific stimulus hierarchy with the physiological profiling, all leading to the decision taking mechanism implementation – represents a strong part of the Intelligent System.

4. MODULAR ARCHITECTURE OF INTELLIGENT SYSTEM

- Generic flight simulator, with specific interface, functioning on subjects' dedicated computers and intended for acquiring the entire information set which will be used by the intelligent system in assessment – see Fig.3. The subject's interface is based on:
  - visual component which simulates the environment, different depending on the specific stimulus weight in flight performance – see Fig.4;
  - specific flight controls component (stick, pedals, throttle);
  - audio component (engine noise, cockpit noise);
  - physiological parameters acquisition component (specific sensors set spread all over the body for blood pressure, pulse, humidity, flight control pressure, visual area focus, EEG).
- Functional integration module: the Intelligent System has to function properly as a whole. All the software packages communicate with each other, the databases can be managed and interrogated, the IT equipments form the network's nodes communicate.
- Specific flight stimulus set elaboration module: there are visual, audio, tactile and psychological stimulus. The last ones are implemented through different simulated environment models, which will stress on individual factors: different simulation environments are included according to the current mission: flight, navigation, retention.
- Flight data set elaboration, integration in simulated environment and physiological parameters elaboration module.

Fig. 3: Virtual airport

Fig. 4: Virtual flight environment

- Investigation, simulation, data processing and optimization procedures elaboration module. The flight data set contains the mission type, the imposed trajectory's parameters (the aircraft's current position according the mission in the 3D space), the real trajectory's parameters flight by the subject (the aircraft's current real position in the 3D space) carrying-off from the trajectory, the flight commands, the real time aircraft's configuration, distinct important time periods, criteria for each mission to be considered achieved.
- Database management module: the database initialization, adding new data, modifying the existent data, applying the

access restrictions, the interrogation capabilities implementation.

- Decision making models module.

5. CONCLUSIONS

Intelligent System for Aircraft Piloting Capability assessment allows high precision assessments of aircraft piloting abilities, by integrating optimization components, aiming to provide the base in decision making process concerning the pilots' and navigating candidates' hierarchy and their admittance in flight training specific programs. It is built as a complex and parametric set of tools, used for the assessment of pilots' flying capabilities in different training stages during the flying school, and for the assessment of pilot candidates' flying potential.

The current version of Intelligent System used in operational stages of flight simulator for pilot performance assessment with standard flight scenarios (climbing or descending flight, with fixed flight path data, initial flight altitude, final flight altitude, glide/slope angle, indicated speed) showed it's consistency in operational tasks.

REFERENCES

1. Adams, C.. The Avionics Behind the Avionics. *Avionics Magazine.* July (1998).
2. Evans, B.. Cockpit Automation: The Good, the Bad and the Ugly. *Avionics Magazine.* May (1998).
3. Matei, P.G., *On Board Equipment: Navigation, Gyro and Data Processing Systems.* Bucharest: MTA Press (2010).
4. Matei, P.G.. Integrated Flexible System for Flying Profiles Assessment. *Aerospace Science Conference „Aerospace 2008"*. October (2008).
5. Matei, P.G., Popa M.. Flight Performance Optimizing System by Improving Pilot – Aircraft Coupling. *National Conference „Aerospace 2005 – Aerospace Science Symposium"*. October (2005).
6. Racoveanu, N., Stoica, A.. *Aircraft Automation.* Bucharest: EDP (1990).
7. Wensley, J.H.. Error Tolerance Implementation. *Fall Joint Computers Conference.* Montvale: AFIPS Press (1995).