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FLIGHT CONTROL OF UNMANNED AERIAL VEHICLE AND MODELS OF CONTROL

RIADENIE LETU BEZPILOTNÉHO PROSTRIEDKU A MODELÝ RIADENIA

Abstract

The target of contribution is systems which Unmanned Aerial Vehicles (UAV) is. Their control and operative systems need complex and sophisticated approach than another, simple systems. The resources for control and decision making in this systems is possible apply mainly convenient adaptive systems and components of artificial intelligence.

Flight control of UAV is ranked among more complicated processes. This needs moderate and individual approach. These are especially decisions for experimental solutions its control.

The contribution contains the main principles and demand on flight control of UAV. It purvey analyse of individual basic models for control with head towards development, with utilization elements of artificial intelligence.

Abstrakt

Cieľom príspevku je zameranie sa na systémy akými sú bezpilotné prostriedky. Ich riadenie a radiace systémy si vyžadujú komplexnejší a sofistikovanejší prístup ako iné, jednoduchšie systémy. Ako prostriedky pre riadenie a rozhodovanie v takýchto systémoch je možné využiť najmä vhodné adaptívne systémy a prvky umelej inteligencie.

Riadenie letu BPP patrí medzi zložitejšie procesy. To si vyžaduje aj primeraný a individuálny prístup. Sú tu hlavne možnosti pre experimentálne riešenia jeho riadenia.

Článok teda obsahuje základné princípy a požiadavky na riadenie letu BPP. Poskytuje analýzu jednotlivých základných modelov pre riadenie a so smerovaním vývoja, využitím prvkov umelej inteligencie.

1 INTRODUCTION

Unmanned Aerial Vehicle (UAV) is relatively little category of techniques and in general present flying, or air-borne vehicle without human aircrew. It is relatively complicated integrated system, in which are reciprocally complement abilities and flying characteristics of UAV with operation abilities of built-in sensor-based techniques and next equipments set (flight control, navigation, data transmission).

The main requirement on modern UAV are mainly sufficient perseverance of fly, high reliability and operativeness of use, low noisiness, and additional.

In present, so much complicated, precise and also expensive UAV is not interested for user. Increasingly, there are asked little and cheap UAV on big technical level. We are witness that also small states and numerically small armies obtain top-class UAV and they learned effectively take advantage of it. However, efficiency of UAV is not only in army. Efficiency cheap and good technical equipped UAV will be offer also in civil sector. Mainly their low-priced (of running is able

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to propose) operation allowed offer effective monitoring, for example: traffic situations, (precautionary) safety risks in the city, at finding of person or at monitoring and evaluation of industrial accident.

Already from title is evident, that it is aerial vehicles without pilot and must be controlled by remote control or automatically. It is necessary ensure flight control, navigation, data transmission, and additional individual responsibilities, for determine of actual UAV. A control, decoding and decision processes on UAV must exactly work automatically. The development is concentrate not only on construction, propulsion unit and system of UAV, but also implicitly on its system control and remote control, on reconnaissance means, operate (digitizing of image, data compression) and transmission information.

2 FLIGHT CONTROL OF UAV

The target of control systems for the random type of flying vehicle is successful fulfilling of all the objectives connected with demanded operation. Between main tasks belong:

- ensure the necessary stability and controllability,
- stabilization of chosen flying parameters,
- systematic controlling at given flying trajectory,
- controlling of flying vehicle dependant on changing conditions and kinematical parameters of its movement.

Flying is an interaction of pilot and aircraft (manual control) or automatic flying – autopilot and aircraft (automatic control) for achievements of given targets. In the case if UAV will be automatic controlling system that exactly replace the pilot’s job from start until landing. Therefore it is necessary to design more elaborated system of automatic control, which has to be able to fill other functions (solve the problem with taking off and landing, solve the unpredictable situations and the influences of the environment, execute and evaluate the information from the sensors...). The necessary condition for control systems is the flying stability, which acts in the way that the small flying deviations caused by destructive elements derogate.

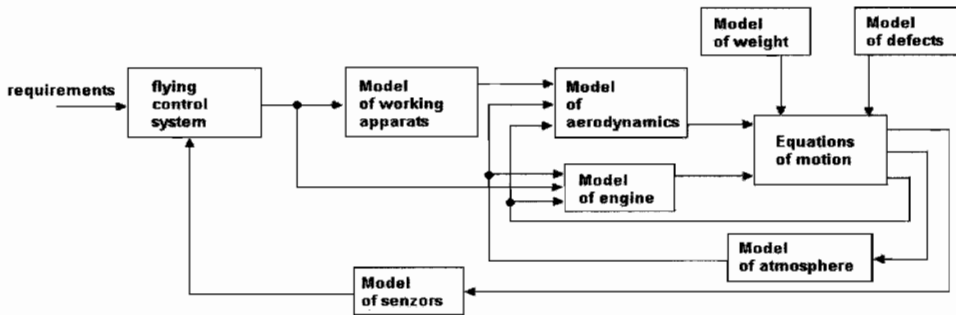


Fig. 1 The model of aircraft and its primary relations

For design of an appropriate control system it is necessary to know the attributes of the system for which is being planned. On that, we use description by mathematical theorems of movement vehicle, which interpret characters, flight performance and system behaviour in individual phases of flight.

The aircraft actually makes two basic types of movement – a sliding one in space and a rotative one around its axes.

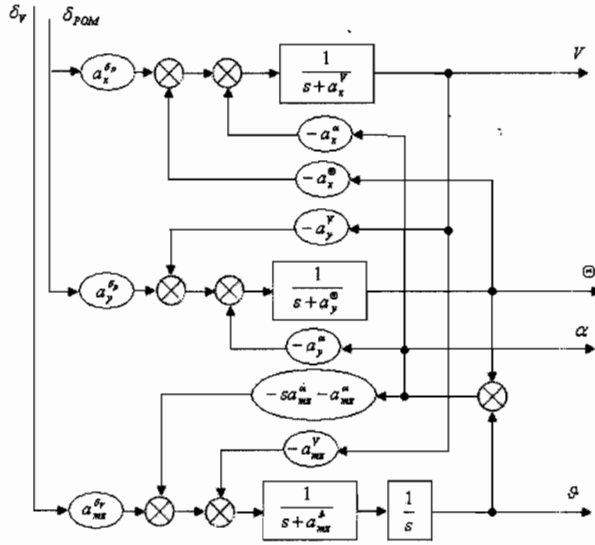


Fig. 2 The model of control aircraft in vertically plane

The aircraft and helicopter have some things in common while controlling. There are regimes and flying stages which are the same for aircraft and helicopter: the flight forward connected with rising or falling, the turns, the way of taking off and landing in a standard style. In these cases the control system is similar; however it is performed by different apparatus. The helicopter has the control system which is applied automatically and the automat changes the angle of the rotor's onset. The helicopters belong in general to the group of flying vehicles which are different from the conception of other flying vehicles. The specific of the dynamic flight of helicopter is characterized by the requirements of oscillation replacement around the centre of gravity, keeping linear movement in the given course and keeping the mode of „hanging“ over the given location.

The controlling system must realise these conditions:

- Stabilization a controlling the angle positions of slope, recumbency and azimuth.
- Stabilization of the flight while hanging also during the flight.
- Absorbing the oscillation of the helicopter in all flight modes.
- Stabilization of the angle turning speed of the rotor's leaves.
- Stabilization of the centre of gravitation of a helicopter on given flight trajectory.

3 CONTROL SYSTEMS FOR UAV

For the model of control systems there is a necessity to know the attributes of the system. In one case we start from attributes of behaviour manned flying vehicles. The whole system should be thoroughly worked out and the control system should be added and then the pilot and his job will replace. Consequently the technical components and control models according to UAV are being modified. The other occasion is design UAV as complex by utilization the latest knowledge from these areas.

We can apply available methods of modeling and simulation for the scheme of such useful system. The modeling is theoretic-experimental informational process where the examined system (original) is unequivocally by other system, physical or abstract which is called the model. It is an

advantage to act according to present position in the area of mathematical modeling. Therefore we can get along from the principals of the scheme by means of the models:

- with the robust control,
- models designed with the method of neuron networks,
- using FUZZY systems,
- others.

3.1 Application of model with robust control

The requirements to flight parameters of UAV demand sophisticated control system which we understand ability to control of aircraft (or helicopter) with cut-down stationary stability, with positive effect on locomotive faculties and higher effectiveness. An aircraft is in connection operative perimeter on opening loop unstable state. It is make use of system synthetic increase stability, which affects quality of control desirable towards. The system for artificial increase stability must be suggested , so as achieved for all flight conditions improvement qualities of control, bigger resistance and robustness towards perturbation of sensors, productive elements and other unknown effects.

The robustness is usually increase by using feedback , which makes it possible to increase measure of stability and good attenuation of perturbations, reduce sensitivity of control to change parameters and external perturbations. There are used two approaches, which make possible solve systems with incomplete information and systems with perturbations:

- adaptive regulators: they estimate parameters and following those are computed principles of control, are considerably complicated then regulators with fixed adjusting;
- the robust regulators: they are not sensitive on changes of parameters and perturbations.

The robust suggestion performs optimal access to the increase of wide zone stability of control systems. A new approach is neural networks, which applied new intelligent technical implementation to identification and optimizing algorithm and they can feature in controlled non-linear systems. Methods of analysis and synthesis in this intelligent technology, which are cognitive and have decision competences that markedly improve controllability of systems.

3.2 Models of control system for UAV proposition by method of neural networks

The basic inspiration of structure neural networks is a neuron model look like computing units and it's connected by synapsis. The signal is usually represented by numerical value, corresponding activity of neuron, which is modified by synaptically weight transition through it. So, knowledges are preserving in synaptically weights no in neurons, which execute only computing function. Learning or adaptation entails change in value synaptic weights, according to choosing algorithm. In term of topological structure and flux of signal we can neurons networks divide into two basics groups: a forward neural network, where the signal is spread only from input to output and recurrent neural networks, where possible spreads of signal round, too.

These structure perfect imitates the live systems than actual conventional computing techniques. Compared to it, they distinguish on parallel processing information. Neural networks are so able to implement large number partial transactional at the same time. The artificial neural networks have especially ability to preserve information, to adapt and learning. Neural network over learnt is able to simulate behaviour of system, whose mathematical description is too complex, or we ever unknown and available is only input data and data, that are output from model of system.

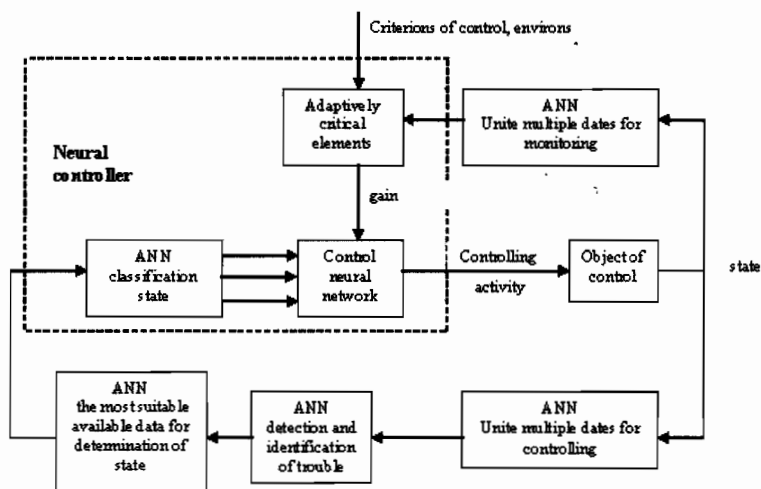


Fig. 3 The principle of control using neural network

3.3 Using of FUZZY system for application in control system

Advantages of applications FUZZY system is ability to work with indeterminate, but complicated mathematically definable datas. Fuzzy modeling and control occupy by modeling composite, non-linear or partly vaguely definition of systems with use fuzzy sets and fuzzy logic in control systems. For capture relations within two or several variable make use of fuzzy approximation, like linguistic approximation. The fuzzy systems are based on base of principle, which makes use of fuzzy logic on representation knowledge and intelligence. Fuzzy control circuit can be suggested so, that roughly imitates of human deductive process. Base of knowledge making by system regulation „if – then”, which are quantified by fuzzy logic uses on representation knowledge of pilot. Fuzzy inference mechanism determines, which rules are the most suitable in momental situation and realize activities expression these rules.

Progress for capture relations within two or several variables contain normalization of variables (transformation), fuzzification (mapping levels of reference) and defuzzification (transmission on real datas).

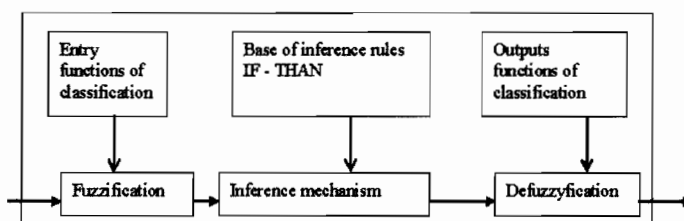


Fig. 4 The common structure of fuzzy control periphery

3.4 FUZZY – Neural networks

Interconnection of fuzzy theory and neural networks is possible realize in several levels. It joins them existing of universal approximation theorem, which explain, that fuzzy regulator (also ANN) is able approximation arbitrary functions, only it is not known with what number of fuzzy rules (at ANN with whose numbers neurons).

The Fuzzy - neural networks afford opportunity works with vagueness. Usually, fuzzy logic is implementation in neurons, that it is i.e. Fuzzy neurons. Fuzzy regulator operates learning of neural networks. Fuzzy regulator is used on control changes of learning parameters during learning of neural networks.

The different assemble method is Neuro – Fuzzy system, which is externally proving look like fuzzy system, which is internally realized by neural network. Neural network is used on generation of base rules for fuzzy regulator. At this approach is applied neural network on generation of base rules according to input data – it is applied controlling learn.

Neural network, realized the fuzzy regulator outgoing from rules of fuzzy regulator into the neural network, which consequential topology of neural network keep organizational correspond to fuzzy regulator.

The result of switch-over neural networks and Fuzzy logic can be very effective, quickly adaptively and self-educationally system. This system is able to enjoy an advantages both principles.

4 CONCLUSIONS

The target of paper has been described approaches and models suitable for application the control system of UAV. The control of UAV request complex and sophisticated approach to control this entity. The controlling and decision process have to ensure processing and scoring of a great information quantity. From this reason the control must be able concurrently operate inputs information. Another problem is big quantity of vagueness, which is very difficult adequate mathematically describe. Therefore using of artificial intelligence in controlling of UAV is the most suitable selection. It is mainly with conjunction of artificial neural networks and fuzzy logic. In the present, the development is very intensive in this area. This fact makes it possible to use theory of automation control which is using components of artificial intelligence to control complex systems.

Next steer will be oriented on investigation of utilization control systems for decision processes and control complex systems. Resources of utilization and implementation artificial intelligence into the control systems can offer effective approach for control full scale of operation systems.

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