NEW WAYS IN THE LIGHT UAV DEVELOPMENT

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1. SUMMARY

Light UAVs (Unmanned Aerial Vehicle) were widely developed all over the world in the past decade. Both carrying platforms and control electronics were intensively researched and developed. The need for devices with reasonable prices created the fast answer of the world market and an abundant quantity of high quality part became available in web shops all over the world. Even parts for military use are available for reduced price. Consequently no more interesting to develop individually UAV systems, but proper selection and integration of ready parts seems to be more efficient.

2. OVERVIEW OF THE UAV DEVELOPMENT IN THE PAST DECADE IN HUNGARY AND IN THE WORLD

During the past decade an intensive research work was carried on both worldwide and in Hungary. The major research centers in the USA are Boeing, Northrop Gruman, Lockheed Martin mostly engaged in the field of heavy UAV systems. In the same time light UAV systems were developed in the USA by companies Aerosond, MLB, Raytheon and many others. Giant companies having governmental commands developing heavy UAV systems leave only a few quantity of technical information about their products. The wide public might have visual information on the USA produced drones during the 2nd Gulf War, when onboard video records from drones were broadcasted worldwide by the big television networks. The other flagship of the UAV development, mainly in the field of light UAV systems is Israel. In that country a tradition of 6 decades of UAV production is yielded to super sophisticated powerful light UAV systems. Plenty of companies are dealing with research and development such as Aeronautics, Top Vision, Elbit Systems and so on. This latter has a special significance in Hungary, as Hungarian Defense Ministry has ordered Skylark type light UAVs from this company. According to our non-confirmed information those Skylarks are providing supporting activity to the Hungarian Defense Forces in their mission in Afghanistan. In Hungary profound theoretical researches were pursued at Zrínyi Miklós National Defense University, Óbuda University and Technical University of Budapest. Results of those researches were used in the production as well, first by Aerotarget Bt. (production activity recently closed) and recently by Hungarian Institute of Military Technology Aero Ltd. UAT (Unmanned Aerial Target) drones produced by Aerotarget Bt. were widely used in the practice by Arrabona Aerial Defense Missile Regiment in the past decade. The Russian Unmanned Vehicle System Association provides the most recent information on its homepage [11], More detailed information are available on this page sorted by categories, countries, companies, types and so on.

Figure 1.
Micro drone developed for US Navy [13]

2.1 Carrying platform

2.1.1 Rigid wing

The rigid wing flying has a history longer than a century. That's why the first UAVs were using the rigid wing technology. Without detailing the early UAV challenges before the 2nd WW, see in other publication XXX, the effective production and wide use of light UAVs was made in Israel, since the beginning of the fifteens of the 20th century. That time the aero-dynamical and structural theories of the subsonic rigid wing were properly known. Consequently their application to small-scale platforms didn't mean any difficulties. The use of new composite materials in the seventies, than the GPS technology with miniaturized control and telemetry systems allowed the development of micro size UAVs. The research and development of micro-size UAVs (less than 300 mm wingspan) is far from solved problem, mainly stability and control of them leaves much room for improvement. A good example of micro drones developed by AeroVironment [13] is seen on Figure 1.

At Dennis Gabor College (DGC) a computer program was developed in aiming to calculate the flight parameters of micro drones [6]. The program is based on an iteration procedure with input data as geometry, aerodynamic and mass data of the airframe to be verified. With that program three drones were developed at DGC.

Figure 2.
Multiple-rotor helicopter drone [14]

2.1.2 Rotating wing

The main advantage of use of rotary wing for drones is the relatively high payload and the low velocity which might be varied within wide ranges. The low velocity allows eventual indoor missions as well. The early helicopter drones were single-rotor types with a look of almost identic that of the grand scale helicopters. The use of multiple rotor helicopters is more and more popular in recent years. The self-evident reason of this popularity is the easy regulation, as there are no complicated mechanisms with moving mechanical parts (subject to eventual failure) in the rotor head. The flight regulation is solved by speed regulation of rotors and the speed regulation is the easiest and safest way of electromotors regulation. The rotors are rigid propellers which may reduce considerably the production costs. The flight of such drones is very stable, both manual and automatic control is relatively easy. The latest update of multiple-rotor helicopters is the miniaturization and the programmable indoor flight with high precision. Such a nano QuadriRotor was developed at Pennsylvania University GRASP laboratory [15]. A fleet controlled indoor flight is solved by that laboratory; see the video on their homepage.

2.1.3 FanWing

One of the outstanding developments of the past decade is the FanWing, developed by American born Patric Peebles. The FanWing is a pseudo rotary wing, in case of which the axis of the rotation is near horizontal. The wing is positioned on the fuselage almost identically as in case of rigid wings. US Patent and Trademark Office registered and published the patent related to this wing in 2001 and 2003 [19]. Makay [1] discussed the new features of this type of drone.

According to the patent description the rotating impeller of the fan produces both propulsion and lift forces. The impeller blades (5) accelerate the entering air, and then orient the flow back and down (1). Consequently the propulsion and lift forces are produced simultaneously. The magnitude of the resulted force depends on the rotor speed. This type of wing allows short take-off (STOL) features. Varying the position of leading edge (7) the air flow (lift and propulsion forces included) might be controlled. The trailing edge (6) forces the flow to be parallel to its plane (Coanda effect). The trailing edge provides the mechanical strength of the wing operating as main strap. Due to forced flow to the upper surface of the trailing edge this type of wing does not show tendency to stall.

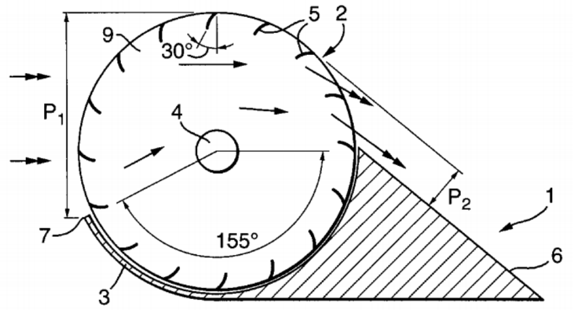

Figure 3.
Cross section of the FanWing [1]

It is clearly seen on Figure 3., how the operation of the FanWing is similar to that of the cross-flow fan which has a history of longer than 120 years. The small Reynolds number cross-flow fan shows higher efficiency than other fans. Theory of cross-flow fans was subject to intensive researches in the 60th and 70th years of the past century at Technical University of Budapest [5]. On the bases of those researches a wide range production of them was started. The small Reynolds number wing and the good efficiency may result in lower velocity, increase of payload and higher action range, so the FanWing [19] can be an intermediate platform between rigid wing and rotating wing devices.

Figure 4.
"FanWing" drone with electric propulsion [19]

2.1.4 Flapping wing

The idea of ornithopter with flapping wing goes back into 4th century BC. The idea is quite evident as birds are flying with flapping their wings showing model for engineers. Plans and wooden models were elaborated in the 15th century by Leonardo. In the early years of the 20th century motorized flapping wings researches showed that the flapping wing was not concurrence against rigid wing structures. In the past few years the expected indoor use of flapping wing structures provoked an upstream in the related researches.

A team of engineers and researchers called "Fullwing" has created an ornithopter that has an average lift of over 8 pounds (1 pound force [lbf] = 4,448 newton [N]), an average thrust of 0.88 pounds, and has a propulsive efficiency of 54%. The wings were tested in a low speed wind tunnel measuring the aerodynamic performance, discovering that the higher the frequency of the wing beat, the higher the average thrust of the ornithopter. [7]

Using governmental support AeroVironment company developed the prototype of a "humming-bird" like Nano Air Vehicle (NAV). That vehicle may obtain 17 km/h velocity in any of the three direction of the space. It can fly forward or backward, right or left side, so the movement of it is also flexible as that of a multiple-rotor drone. The wingspan is 16 cm and the total flying weight is 19 gramms, including the control system, the camera and the battery as well. According to the results of the test flights that system is a very promising one for indoor operation. The biggest disadvantage of this system is the relatively complicated mechanical drive of the wings, showing potential failures [8].

Figure 5.
Artificial hummingbird [8]

2.2 Control and other electronic systems

According to the current FAI regulation flying models are always under remote control from the ground by visual control, while UAV may operate without remote control by means of GPS or other satellite based control system. However traditional radio control is used in case of many UAV systems during the take-off and the landing phases of the operation.

Traditional radio control systems are widely used in the aero-modeling in 27, 35, 40 and 80 MHz bands. Due to their noise sensitivity and low action radius they do not meet any requirement of military use. Recently the use of 2,4 GHz radio control systems is more and more popular. The default encoding of 2,4 GHz systems allow limited military use as decoding of them requires extra effort from the enemy observer. Once the plane is in the sky, it may continue its travel without any radio contact with the ground control point. Intelligence data are transferred via secured radio contact.

Several GPS based control systems are developed all over the world. Molnár [3] at Zrínyi Miklós national Defense University developed such a control system used both in intelligence and target UAV. At the same university, Turóczi [4] developed a control system for a quadric-rotor UAV.

A wide range of GPS based control systems is available on the international market [9, 10, 17]. Autopilots for civilian use are widely used by modelers. However their price is relatively high 1000-5000 USD according to configuration. Even Hungarian autopilot system is available on the market.

3. READY TO FLY SOLUTIONS ON THE DEFENSE AND CIVILIAN MARKET

Due to the globalization of the market all civilian product is available on the market any time. Even it is quite difficult to separate products fitting the needs of defense and civilian market as civilian products with high quality parameters may satisfy the requirements of military purpose products, too. To carry a payload of 1-2 kg mass, to a distance of 15-20 km, does not mean any technical difficulties, so a suitable platform can be selected from a modeling site. Then the upgrading of the selected platform is feasible with more powerful parts also available on the global market. Such a modeling site with reasonable prices is the Hong Kong based HobbyKing [18].

4. CONCLUSIONS

- Carrying platforms and control elements for light UAV are available in abundance on the world market. Consequently instead of individual development the proper combination of well selected parts yields to easier and efficient results in UAV building.
- Miniaturization for indoor missions requires new developments both in the field of platforms and electronic control devices.

5. REFERENCES

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