MULTICOPTER LANDING

Jaromir HOSEK

"University of Defence, Faculty of Military Technology, Brno, Czech Republic
(jaromir.hosek@unob.cz)

DOI: 10.19062/2247-3173.2016.18.1.62

Abstract: *Paper presents the methods to help the landing of the Unmanned Aerial Vehicle. There are mentioned two other methods and depicted method based on the Neural network. The main idea of that approach is described. The paper solves landing of the Unmanned Aerial Vehicle by means of camera only.*

Keywords: *unmanned aerial vehicle, unmanned ground vehicle, landing problem.*

1. INTRODUCTION

The new term used in these days is the Unmanned Aerial Vehicle (UAV). Strictly speaking, it is an aircraft without human pilot aboard and we can say it is the Unmanned Aircraft System (UAS). Nowadays, public use the term drone widely, because there is a big similarity to sound of the flying male bee.

The Unmanned Aerial Vehicles (UAV) are used in private sector and, of course, in security branch. The private sector have many types of the UAV from small miniature weighting to 1kilogram up to very heavy UAV weighting tens kilograms. There are used fixed-wing and rotary-wing UAV. The smaller types we can buy in a children stores and playing with them to attract children to study technical branches. The higher types are used in commercial. The examples of using are:

Power engineering – the UAVs are equipped by cameras and they serve to monitoring wind power stations, refineries, opencast mines, photovoltaic power stations, gasworks, etc.

Agriculture – monitoring of crop, an insects, the fungal diseases, moving the wild animals, etc.

Building industry – check of a roof condition, the high smokestacks, the transmissions towers and nowadays very important measurement of the heat losses, etc.

Environment – measurement of the atmosphere, the atmosphere pollution and monitoring hazardous waste dumps, etc.

Culture and entertainment – propagation of the cities, the historical sights, the interest places, the sport and culture actions, etc.

Transport industry – monitoring the streets, the highways, the floods, the snow calamities, etc.

There are many other and other field where the UAV can be used to improving and speeding up some activities. The main field of using is in the security branch, it is meant the search and rescue systems, the reconnaissance for military and police, for observing demonstrations and big sport actions (football matches, etc.), searching the lost persons and guarding of dangerous areas like the ammunitions storages, the chemical factories or damaged nuclear power stations (Fukushima, Chernobyl).

We can find many other ways to divide the UAVs, this is according to a number of motors, UAVs weight, equipment on board etc., it depends on authors and their preferences.

2. COOPERATION BETWEEN UAV AND UGV

There are many types of the UAV which are used in security branches. We have small UAV (multicopter) with rotary-wing, type Y6 which is equipped by three servomotors and its weight is about 1,5kg and payload is 0,400kg. Its main advantage is ability to vertical takeoff and landing and of course to hover above or in front of interesting place. This UAV can hide behind a tree, a building or any obstacle to observe important things. The advantages of these multicopters are small dimensions and because of that to operate quietly and of course furtively and if necessary secretly.

The big problem of such small multicopter is mainly energy. They can be in the air about 10-15 minutes, this is flying range about two kilometres. We can use another battery pack but a payload will be decreased.

The unmanned ground vehicles (UGV) are very popular too. Their control is nearly the same, remotely control, they use GPS, accelerometers, rate gyroscopes, magnetometers and other sensors based on the MEMS technology. They range is longer and they have not any problem with energy source and their payload is incomparable with the UAV. The UGV has smaller ability to discover large area in a short time. The question is: can we use an advantages of both unmanned vehicles? The answer is why not. The UGV can serve like carrier of the UAV and if necessary to charge its batteries. The problem is that both vehicles are remotely controlled and operators must cooperate during landing on the UGV. The operator controls multicopter by means of camera and after some stressful mission the landing manoeuvre is very difficult. As mentioned above multicopter use visual (VIS) and infrared (IR) cameras. These cameras are primary used for information to user and for navigation, guidance and control, the same like primary guidance sensor of birds, insects, etc. The main idea is to use untapped potential of the cameras for automatic landing on UGV ramp.

3. OTHER APPROACHES TO SOLUTION

The landing problem is solved by many ways and by many researches. I was interested in two ways of solving this problem.

3.1 Assisted landing. At first it is very interesting to take advantage of control system of the UGV. The idea comes from using onboard VIS and IR cameras to recognize the UGV carrier and by means of visual data to control landing. The authors proposed to place the light blinking diodes on an UAV bottom. The UGV ramp will be equipped by a camera. This camera tracks the position of diodes and microprocessor counts distance and orientation of an UAV and counts differences this is coordinates Δx, Δy, Δz and angle $\Delta\alpha$, as shown in Fig.1. The counted differences are led to the UGV control system which turn vehicle to right position due to the UAV.[1]

3.2. Landing by means of beacons. The main idea is nearly the same, the landing place is very small and multicopter use a camera for measuring of all parameters of the control system for landing. The signal wall for landing is placed on ground in vertical position and it is equipped by the radiations sources (beacons). The sources are tracked by the camera fixed on an UAV. The one radiation source do not enable the landing Fig.2a. The four sources enable landing but undirected landing, Fig.2b. Due to the authors use five radiation sources which are arranged as shown in Fig.2c. The inputs of a camera are

convert through threshold method to binary picture by means of MATLAB function *graythresh* to rectangular grid and occupied fields in the grid are positions of beacons and control system can determine its position to source's wall. [2]

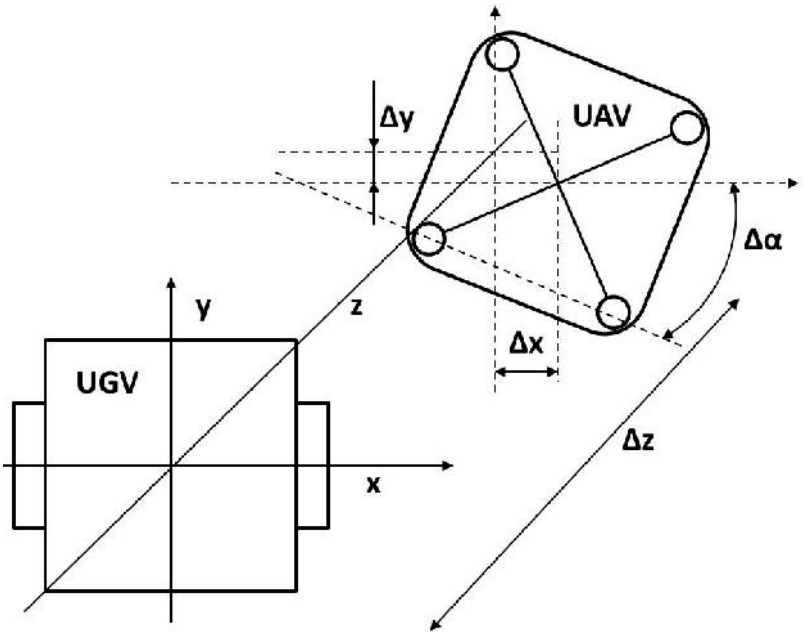

FIG.1., Basic coordinates between UGV and UAV

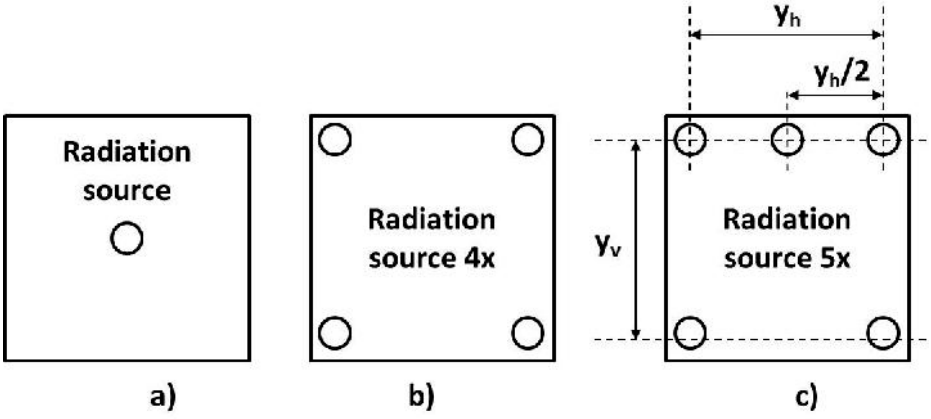

FIG.2., Placement of the radiation sources

4. NEURAL NETWORKS AS DECISION ELEMENT

There are many variants how to solve takeoff and landing of the small multicopter. The one of the variants is to use neural networks.

The big problem during using of the multicopter is landing. We assume the small multicopter equipped with a camera and landing on a determine place for example a ramp. The ramp is equipped by passive element which enables to gain the landing parameters for control system of the multicopter. The suitable element is the circle, Fig.3a. The circle drawn on a ramp enable only landing but without orientation because of that it is needed to add other elements. These elements are other circles but smaller and placed in determinate pattern. There is chosen triangle of which vertexes are small circles

as shown in Fig3b. The patterns can be various and the circles can be arranged in shape of big letter L Fig.3c or can be used five circles etc.

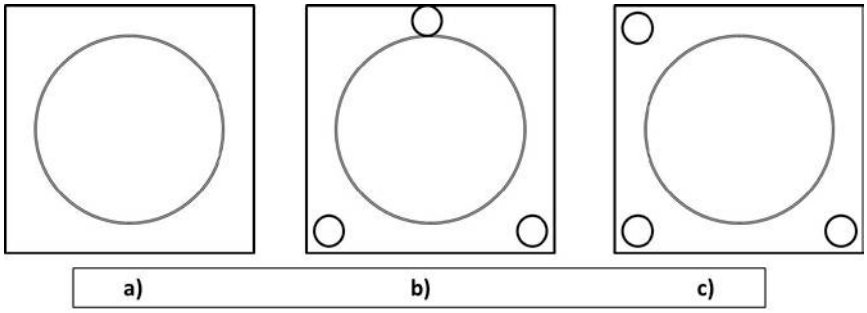

FIG.3., Pattern on a ramp

Main idea is that when we see on the circle from any angle we see the ellipse. We assume that the camera approaches and an ellipse changes to a circle, Fig.4. The landing without orientation can approach from every course and control system evaluates changes from an ellipse to a circle, and when a multicopter is above a ramp the control system see the circle and can land. The oriented landing needs other information about the front part of a ramp. When a multicopter is above a ramp and see a circle the control system must detect three circles in a vertexes of triangle and rotate in accordance with them.

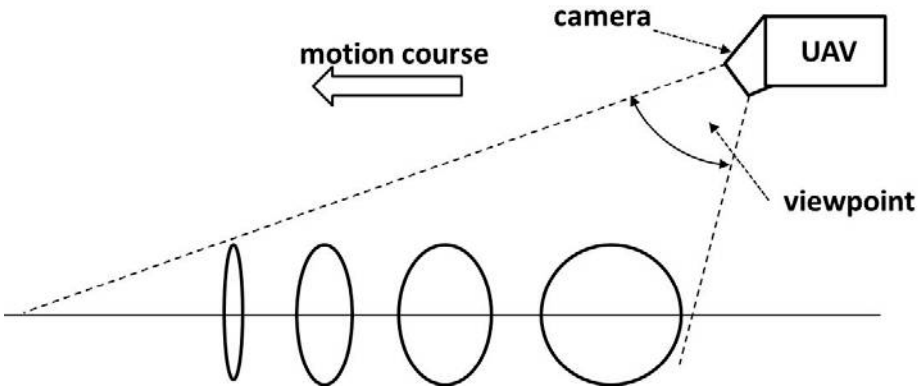

FIG. 4. Changes ellipse to circle

The decision element of the control system is the neural network. The neural net is trained on recognition of the various shapes of the ellipses. The motion course and a velocity of a multicopter depends on the shape of the ellipses. The shapes are divided into 4 main categories. The first category, the ellipse is very narrow and it means basic approach to a ramp. The second, when an ellipse is wider, the velocity is decreased and the course is the same. The third one, the ellipse is wider again and a velocity is decreased again too. The last stage is when an ellipse is (nearly) the circle, the velocity is stopped and multicopter is prepared to landing and a neural net recognize three additional circles to determine orientation of the multicopter, Fig.6. The output of the neural network may be set in accordance to a ratio of a small half-axis to a big half-axis. The neural network output setting depends on the type and the size of the multicopter, Fig.5.

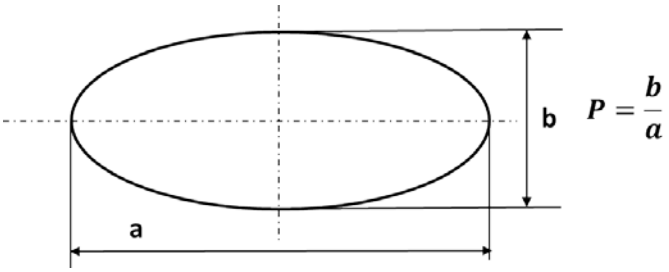

FIG.5. Neural Network setting

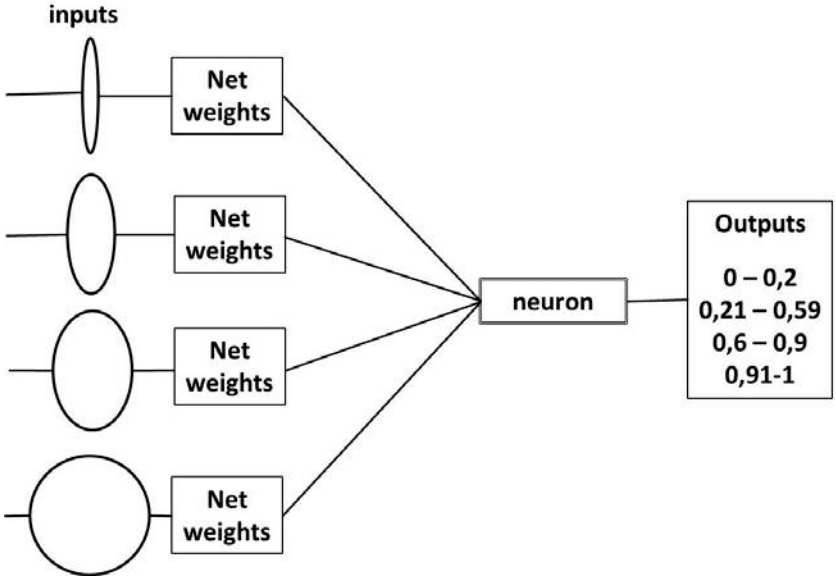

FIG.6, Neural network

CONCLUSIONS

The modern UAV are used for an entertainment and for more important things like searching or guarding. The last ones require long time operation this is long time flight above interesting area. To make flight longer we can use cooperation between the UAV and the UGV. The presented method for using neural network during landing can increase of an effectivity of the UAV using. When the visibility is sufficient the circles can be passive, on the other hand during unfavourable weather conditions the circles must be active, for example light up circles or circles must shine.

REFERENCES

[1] Y. Bergeon, R. Doskocil, V. Krivanek, J. Motsch, A. Stefek, *UAV Assisted Landing on Moving UGV*, ICMT2015, Brno, May 19 – 21. 2015, University of Defence, p.611-615, ICMT 978-80-7231-976-3;
[2] M. Polasek and J. Nemecek, *The utilization of the videocamera for the unmanned aerial vehicle control*, ICMT2015, Brno, May 19-21. 2015, University of Defence, ICMT 978-80-7231-976-3;
[3] J. Wesley Hines, *Neural Approaches in Engineering (MATLAB supplement)*, John Wiley and Sons, New York, 1997;
[4] M. Novak, *Umělé neuronové sítě*, C. H. Beck, Praha 1998, ISBN 80-7179-132-6;
[5] S. Russel, P. Norvig, *Artificial Intelligence a Modern Approach*, Third Edition, Pearson Education Limited, 2014, ISBN 978-1-292-02420-2;

APPLIED MATHEMATICS, COMPUTER SCIENCE, IT&C