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Proposed Algorithms for Aerial Target Tracking

Anita Singh

Abstract— **This paper provides a calculation technique for the autonomous Ground Tracking System. The technique developed performs path planning of launched weapon as well as of moving target. The path planner uses coordinate geometry laws and incorporates a height change mechanism that is triggered where necessary. Simulation can be performed taking into consideration that the aircraft also needs to visually track using a mounted camera. The camera is also interfaced with Automatic Ground Flight Control Computer, to get input about the position and orientation of the aircraft .This study proposes three parallel algorithms, selected according to characteristics of target.**

INDEX TERMS— **Angle of Fire (AOF), Automatic Ground Flight Control System (AGFCS), Ground Tracking System (GTS), Horizontal angle(φ), Laser Range Finder(LRF), Range(R), Time of flight(TOF) , Vertical angle(Θ),**

I. INTRODUCTION

An interesting problem for Ground Tracking System (GTS) is to do automatic detection and tracking of aerial targets. As the location, bearing, and azimuth of the sensor change, the image of the target will appear to shift and rotate, and possibly change in scale. Hence, Ground Tracking System (GTS) has to increase perceived utility with the availability of better hardware. In particular, it is now possible to fit enough computing power on-board such small devices to achieve useful mission objectives. While the considerable problems of ensuring that the firing station is stable or that can move in a stable fashion. GTS can be largely relegated to small and lightweight commercial control box called Automatic Ground Flight Control System (AGFCS). The Ground Tracking System (GTS) is designed to explore the design of a vehicle, whose high-level goal is visual tracking. The hardware components of GTS consist of a camera mounted on a two-axis gimbals, Laser Range Finder(LRF) , GPS, a commercial AGFCS, a small on-board computer and radio links all mounted on a stable platform. This hardware is designed to be capable of autonomous visual tracking of aerial targets, the latter being selected in flight from a ground station. The hardware components and basic tracking algorithms employed in GTS are discussed in this paper. At the time of writing this paper, the status of this hardware is that the tracking algorithms are being commissioned for only the constant velocity moving aerial target. The hardware development is proposed for simulation and will be incorporated with GTS. Main simulatation is dependent on these algorithms. The goal is to determine the future position of aerial target and kill the target accurately with in feasible time limit. Thus for reduction of failure probability, our major goal is to develop algorithms for different approaches. However, the acceptability of these algorithms is depending on implementation in software and hardware. These algorithms are path planners, which approach to model target path as well as launched weapon path. The role of Automatic Ground Flight Control System (AGFCS) is to detect and track aerial target. The optronics of AGFCS is very important as , the gimbal is mounted under the GTS . φ is the heading of the camera with respect to the aircraft and has a range [0,360], 0 being the direction of the aircraft and clockwise direction being positive. θ *is* the elevation of the camera with respect to the aircraft and has a range [0, 90], 0 being straight ahead and 90 being straight upward. The target coordinate system [1] is related to world coordinate system by three angles i.e. *yaw*, *pitch* and *roll*. The inputs to GTS are range, vertical angle and horizontal angle (R,θ,φ) of the target. The AGFCS will have to control all the necessary computation and provide interface with sighting system and servo system. The sighting system , servo system and AGFCS are interfaced through serial interface This study directly helps AGFCS .

Anita Singh, Sceintist-D, Instruments Research & Development Establishment,DRDO,MinistryOf Defence, Dehradun-248008, Uttarakhand, India.

The determination of future position of aerial target to kill the target accurately with in feasible time limit is a well known problem for AGFCS. Thus for reduction of failure probability, major goal is to develop an algorithm for pre specified [2] approaches. However, the acceptability of these algorithms is depending on implementation part. The use of algorithms is to calculate the fire angle and to select the techniques contributing to the trajectory modeling part. The role of Automatic Ground Flight Control System (AGFCS) in optronic fire system for anti-aircraft weapon system is to compute the fire angle to be imparted through servo interface unit. The trajectory of launched weapon is related to weapon characteristics [3]. The inputs to AGFCS computer are range, vertical angle and horizontal angle (R,θ,φ) of the target and some metrological parameters like air temperature, atmospheric pressure, wind velocity etc.The AGFCS will have to control all the necessary computation and provide interface with sighting system and servo system.

II. TARGET TRACKING THROUGH ITERATIVE METHOD

The software architecture of AGFCS will be responsible for driving the control of hardware. While, the software is a module that computes target trajectory and angle of fire [5]. computation will also be part of this software. So, target tracking and finding killing range is a very important part of computation. We take the same presumption about aerial target model for this proposed work. The iteration method is common in all techniques used to find the position of moving target. The working principle of this method is prespecified in detail in our previous study[2].Here the algorithm is described for iterative method.

A. Algorithm for iterative method

1. Start
2. Get at least three target positions (R,θ,φ).
3. Convert the polar coordinates into cartesian coordinates.
4. Perform smoothing of the data points.
5. Calculate the next point (i.e. next position to this current point) and find the average velocity of target.
6. Calculate TOF of target to reach upto next point.

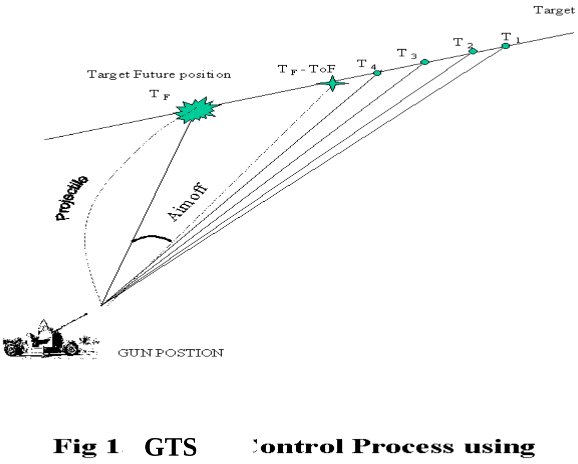

Figure 1. Iterative Technique Process

7. With computed current position coordinate and TOF of target
   Go to 5

   If

   TOF(Target)= TOF(launched weapon),

   for this new point Go to 8

   Else

   Go to 5

III. COMPUTATIONAL MODELS FOR AUTOMATIC GROUND FLIGHT CONTROL COMPUTER

A. Shortest time technique

In this technique, with the current position of target, we can calculate the future position with some standard arbitrary time instant.

- Arbitrary time instant = current time instant + time of flight for arbitrary range + weapon laying time + computational time .

In this technique target reaches at this calculated time instant the fire is released just before.

- *Algorithm for Shortest time technique*

1. Start
2. Get at least three target positions (R,θ,φ) .
3. Convert the polar coordinates into cartesian coordinates.
4. Perform smoothing of the data points.
5. Calculate arbitrary time instant (ATI)
6. Calculate the next point (i.e. next position to this current point) and find the average velocity of target.
7. Calculate TOF of weapon to be launched to hit at future position.
8. Calculate TOF of target to reach up to next point.
9. With computed current position coordinate and TOF of target

   Go to 5

   If

   TOF(Target) – (TOF(weapon)+ATI) = 0.01,

   for this new point then, go to 10

   Else

   Go to 6

10. Calculate angle of fire for this new point.
11. Send the signals to servo interface.
12. Stop.

B. Closest point technique

This technique, hits the target at position where angle between line of sight and tangent to trajectory is perpendicular. This point is called closest point. The advantage of this proposed technique is only for special kind of ammunition (like gun ammunition, artillery) because in this technique the deviation due to weather effect is very small but having greater risk for firing station.

- *Algorithm for Closest time technique*

1. Start
2. Get atleast three target positions (R,θ,φ) .
3. Convert the polar coordinates into cartesian coordinates.
4. Perform smoothing of the data points.
5. Calculate the next point (i.e. next position to this current point) and find the average velocity of target.

6. Calculate TOF of target to reach upto next point and angle of elevation for this point($\Delta\theta$).
7. Calculate TOF(weapon) for this point.
8. With computed current position coordinate and TOF of target

If [($\theta + \Delta\theta = 90^{\circ}$)&&(TOF(Target)= TOF(weapon))]

then ,Go to 8

Else

Interception by this technique is not possible.

9. Calculate angle of fire for this new point.
10. Send the signals to servo interface.
11. Stop.

C. Pre-selected range technique

In this technique, the computation is carried out for pre selected firing range. We have to work out for all possible directions. The advantage of this proposed technique is that it is very useful approach for too high velocity target [6] because in this approach all the ballistic computations are carried out early. Once the target comes from any direction then only time taken in weapon positioning.

- *Algorithm for Pre-selected range technique*

1. Start
2. Get atleast three target positions (R,θ,φ) .
3. Convert the polor coordinates into cartesian coordinates.
4. Perform smoothing of the data points.
5. Find the direction(D) of the target.
6. If

[(R ≈ Pre selected R) && (D ≈ Corresponding D)]

Then, Go to 7

Else

Go to 2

7. Find the future position from our pre calculated work with the help of corresponding (R,D) and take a value of angle of fire for this new point.
8. Send the signals to servo interface.
9. Stop.

IV. CONCLUSION

These algorithms help in designing of software for AGFCS , which computes the angle of fire to be imparted to the weapon to hit aerial target. Based on target speed, direction & time of flight of the launched weapon, we can hit target accurately. The problem of tracking and selection of killing range may be solved by any technique. However, the selection of technique is decided by the velocity of the target. It seems that a single technique is not suitable for all kinds of aircrafts, but the selection of technique needs proper observation of target, which is done by iterative method. This paper enhances current report about these techniques & gives proper algorithms. The implementation part is yet to be explored.

REFERENCES

[1] Command of Army Council, "Text Book of Anti-Aircraft Gunnery", Harrison And Sons Ltd., Vol 2,1924.

[2] Anita Singh, Anil Kumar & Sunil Uniyal, " Proceeding of International Conference on Mechanical and Aerospace,"Analysis of different approaches for gun ammunition to hit aerial target".

[3] Anita Shakarwal, Madan Singh Rawat, Anil Kumar, "Estimatiom of required correction for gun simulated trajectory" Proceeding of International Conf. of System Dynamics and Control 2010,Manipal Instt. Of Technology,Karnatak, pp.97.

[4] Anita Shakarwal, Madan Singh Rawat, Anil Kumar "Ballistic solution modeling of gun ammunition to hit aerial target" , proceeding of American Institute of Physics Journal ,978-0-7354-0854-8/10.pp186-191.

[5] Ikram-ul-haq, Chen jie, Zhong qiuhai. "Modeling of ballistic solution based on ammunition data for tank fire control system", Dept of Autom. Control, Beijing Inst. of Technol., Beijing, 2008.

[6] Text Book of Ballistics and Gunnery, London Whyman & Sons: Part I, 1927.