Intelligent Guided Missile

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***Abstract*—Guided missiles involve the use of conventional algorithms like proportional navigation algorithm and its variants which is optimal when the speed advantage of guided missile is very high and the maneuvering capability of the target is low. When the traditional navigational algorithm is pitched against the present fifth generation aircrafts which employ fly-by-wire technology for high maneuverability and added with speeds between Mach-2 and Mach-3, the system's efficiency drastically decreases. The missile needs to have a much higher speed advantage or to use a combination of artificial intelligence and modern control algorithms. Techniques to keep the guided missile airborne and results of pursuit and evasion with an autonomous intelligent agent incorporated in the control loop is presented.**

Keywords-launcher; misdistance; agent; autonomy

I. INTRODUCTION

In the 21st century wars are being won by the nations with superior air power, for example U.S invasion of Afghanistan and Iraq. In these wars Missile Evasion by fighter aircrafts or deep penetration aircrafts or by long range bombers is an important thing to observe. So it is necessary to have a salvo to effect kill of an aircraft that has executed an escape maneuver. The software package available in the weapon system sector such as Farn Borough, DRA, GU14, etc, helps to simulate missile evasive maneuvers so as to increase the survivability of an air craft against missile threat. The two main advantages of the present generation of aircraft over missiles are their high speeds and high maneuverability. It has if N missiles are available on the launchers at any time no more than N/3 or N/2 enemy aircraft can be shot down based on the doctrines adopted by different armies. With escalating cost of a missile and the potential damage that an intruding aircraft can cause, there is a need to improve the single shot kill probability of a missile to hundred percent. Recent advances in distributed Artificial Intelligence such as deploying intelligent agents (IA) hold promise of improving the performance and decreasing the misdistance (distance between the target and the closest point of approach of the missile to a small value).

The word agent means one which searches among options and makes a suitable offer matching the price one can pay. Intelligent agents are software entities that perform a similar function. They come under the category of distributed Artificial Intelligence, and are associated with problem solving functions. They are characterized by some general attributes like autonomy, social ability etc, as shown in Tab. 1.They perform as co-operative problem solvers in a multi agent environment, or as single autonomous agents. Typically, the functions they perform are negotiation and exchange of information with other agents to solve a problem in a multiple agent context. The Intelligent agents can be characterized by their functions, such as interface agents, information agents and task agents etc .an information agent provides intelligent access to a heterogeneous collection of information sources. An interface agent extracts relevant information and passes it on to the user. A task agent performs the desired task, be it goal-oriented coordination or implementation of an action to achieve the goal. In this paper the task agent has been referred to as an intelligent agent to distinguish it from other agents.

II. TRADITIONAL MISSILE GUIDANCE

Constant line of sight (CLOS) or augmented proportional navigation (APN) [1] are the two most popular guidance laws employed in missiles to pursue a target, either in an all-the-way command-guidance-missile or in a missile fitted with terminal homing. In this paper, missiles guided by PN guidance law are considered. The scheme of interconnection of components of a missile is shown in Fig. 1. From the launch to the time when terminal homing takes over, signals from ground based radar are received and processed by the receiver unit onboard the missile.

TABLE I. ATTRIBUTES OF INTELLIGENT AGENTS

Attribute	Functions
Autonomy	Ability to operate without direct intervention of humans or others
Social ability	Ability to communicate with humans and others agents
Reactivity	Ability to perceive the environment and respond to changes in it
Pro-activeness	Ability to take initiative and exhibit goal-directed behavior
Intelligence	Having human like mentalist notions of knowledge, beliefs, intentions and obligations.
Rationality	Acting to achieve its goal and not preventing its achievement.
Selectivity	Ability to focus attention on what it needs and ignoring the rest.

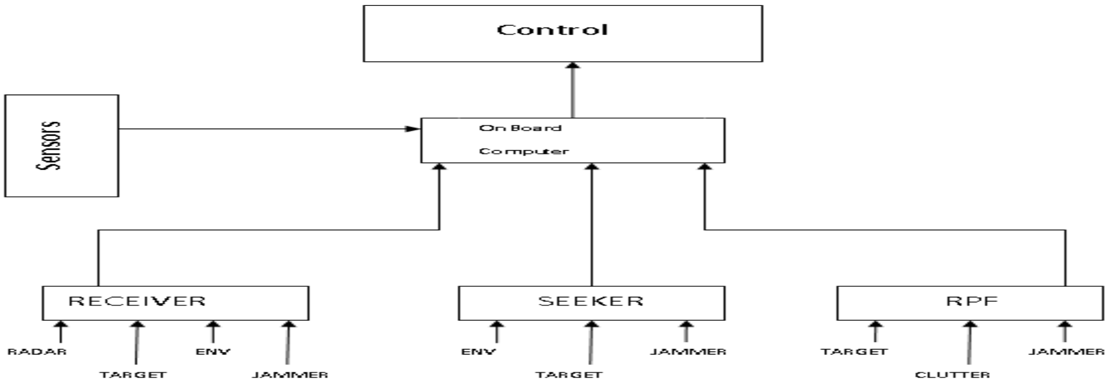

Figure 1. Conventional interconnection of sub-systems in a missile

The signal environment can be hostile, if jammers are present. The signals include identification code and command signals, commanding the missile to steer towards the target. The receiver unit contains signal processing software. Processed commands to the On Board Computer (OBC). In the extreme proximity of the target, the radio proximity fuse amplifier communicates signal to the OBC besides triggering the explosive chain in the warhead. The OBC, in addition, constantly monitors the state of sensors like accelerometers, angle-sensors of the control surfaces, dynamic and static pressures, etc, and fusing this information, generates steering control commands and communicates them to control unit that controls the missile motion. Under the most circumstances, the guidance law is adequate to affect the kill [2]. PN algorithm is expressed in the generalized form, as given in (1).

$$\alpha = L\lambda \times \omega \quad (1)$$

Where L is normal direction of the command acceleration (latex); ω, angular velocity of the line of sight (LOS); and λ is the navigation constant. To account for the maneuvering target, the PN algorithm by 'ατ' the measured acceleration, as given in (2).

$$\alpha = (L\lambda\times\omega) + \alpha\tau \quad (2)$$

Since APN makes use of extra information, knowledge of the target maneuver, the missile is expected to be more efficient with lower demand on acceleration. However unfavorable conditions exist which include target maneuvers, saturated axial accelerations, intermittent loss of guidance commands, measurement errors, tracking noise, etc. Serious limitation in performance is noticed when the target takes maneuvers. For example, in maneuver M3, the target aircraft senses the approaching missile either through its own sensors or through intelligence and makes a maneuver. The maneuver is to turn towards the missile for some period followed by a turn in the opposite direction. With the relative distance between the missile and the target as variable, the missile motion under APN guidance law is simulated. The results show that in simulation where complete information (state variables-position coordinates and velocity vectors) is available to both the pursuer and the evader, APN algorithm is not always adequate.

This paper is aimed to demonstrate the efficacy of incorporating AI in the form of an autonomous intelligent agent in a missile. The two subjects are dealt with extensively in the references cited.

III. Intelligent Agent Based Architecture

To deal with the situation described above, an Intelligent Agent (IA)-based architecture is proposed, as shown in Fig 2. This is a multi-agent system in which each block is equipped with an agent with limited but pertinent information. The IA interacts with the information agents.

The IA [3] continuously interrogates these information agents. Under normal circumstances, the IA allows the OBC to control the missile. When the IA senses a situation (a maneuver) which is known to be beyond the capability of the OBC of the missile [4], it invokes an expert system, disables the

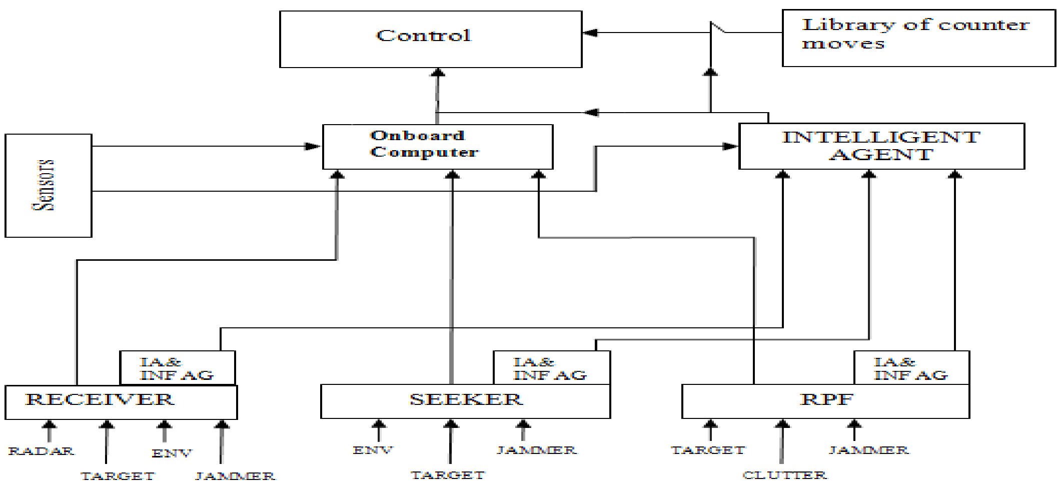

Figure 2. Intelligent Agent Based Architecture

OBC and enables the expert system to take over the control [5] of the missile. In the Fig 2, the library of countermoves consists of several expert systems, relevant to different phases and kinds of missile-aircraft encounters The time-optimal control of a system is usually a trajectory from any initial point to a given terminal point can be achieved in the shortest possible time by employing maximum lateral acceleration (Latax) followed by maximum deceleration with the switching time as the determining factor. This principle is invoked to form the algorithm of the expert system in the present case.

ALGORITHM

STEP 1

IF

The relative range (Rr) between the missile and the target aircraft is less than 2.5 km.

THEN

No changes in the guidance law i.e., continue APN.

STEP 2

IF

2.5 km< (Rr) <6km, and

IF

Latax is saturated at one side for more than 1.4 s

THEN

Force latax to saturation in opposite direction for 1.6 s, and accept OBC command, and fire STEP 2.

IV. Airborne Surveillance Cum Missile

The above section has discussed how to deal the maneuvering capability of the target i.e., aircraft or any flying target. This section will discuss about how to decrease the speed-advantage of the target and increase the surveillance and securing the exclusive air zones and ground targets. In this proposed system we control a missile on fixed or variable loops through radio frequency or with any other powerful wireless link. The on-board radar based sensors on the missile will detect any hostile ground or air activity the missile will directly break from the wireless ground based link and then the control is shifted to the intelligent agent and the series of counter moves will be affected to shoot down the enemy intruder. By this modification the already airborne missile will have much lesser reaction time compared to the traditional radar based and ground stationed SAM(surface to air missile entities), there by effectively saving the time and increasing the kill probability of the missile. The proposed modification is shown in the Fig. 3.

V. Results and Discussion

The results indicate that in all cases, the IA has successfully handed control to counter the evasive move maneuver of the target. The missiles with traditional navigational algorithm which would be wasted can be utilized efficiently by using proposed algorithm. While the evidence is in favor of an Intelligent Agent, software reliability must be ensured in the system design. There should not be any hitch or uncertainty in handing of control from on-board computer to an expert system.

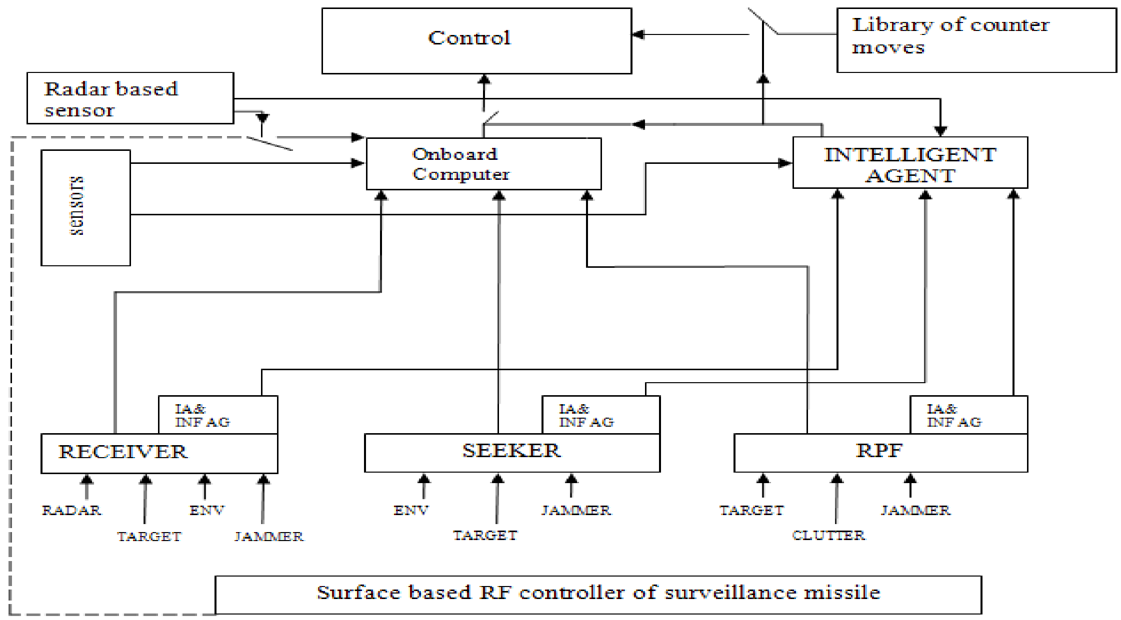

Figure 3. Airborne Surveillance cum Missile System

Maneuvers and counter moves, like electronic counter measures and counter-counter measures are perpetual and progress with technology. It is almost impossible to initiate the maneuver at the exact time. Hence, the aircraft commences maneuvers while entering the threat zone both to confuse the fire control and out- maneuver the missile. Based on the simulation data available, it is possible to state that incorporating an IA system on-board a missile will enhance the kill probability or even achieve the most coveted fire and forget capability.

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REFERENCES

[1] MacFadzean, “Surface based air defense systems analysis”, Artech house.pp163-66.

[2] Philips.C, “Computational methods for determining missile engagement envelopes”, Am. Inst. of Aeronaut and astronaut, 91-0588.

[3] V. Krishnabrahmam, N.Bharadwaj, K.N.swamy, DRDL, Hyderabad. “Guided missile with intelligent agent” Defense science journal, vol.50, pp.25-30, January 2000.

[4] V.V.S.Sarma, IISc, “Intelligent agents”, J. Instn Electron. Telecom. Engineers. 1996, 42(3), 105-09.

[5] Leitmann.G, “An introduction to optimal control”, Mcgraw Hill, Newyork,1967