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RESEARCH ARTICLE OPEN ACCESS

Adaptive Missile Guidance Using GPS

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Abstract:

The name adaptive refers to the ability to direct any missile using GPS in any critical situation. GPS guided missiles have superior navigation and surveying capabilities. With the help of the GPS satellite system, warheads could be delivered to any part of the world using the border of the onboard computer in the missile. GPS enables precise targeting of military weapons such as ICBMs, cruise missiles, and precision guided weapons. For use in 155mm, weaponry projectiles with embedded GPS receivers capable of withstanding 12,000 G accelerations have been developed. To reduce multipath errors, a variety of techniques, most notably narrow correlation spacing, have been developed. In moving vehicles, the multipath effects are much less severe. That is, when the GPS aerial is moving, false solutions based on reflected signals quickly fail to cover, and only direct signals produce steady solutions.

Keywords — ***Adaptive, Missile , GPS , Satellite.***

INTRODUCTION

Missile guidance systems have advanced rapidly in recent decades. Recent technological breakthroughs ensure that smart warheads will play an increasing role in maintaining military superiority. The primary missile guidance concerns are mostly dependent on when the missile receives commands to move along a specific path to the target. These commands, however, are generated by the missile computer autopilot in some cases. On the other hand, commands are sent to the missile from outside sources. The missile seeker or sensor is a component that generates missile data for the missile computer. [1] The computer processes this data and then generates the guidance commands. Sensor types that are commonly used today include infrared, radar, and global positioning systems.

Radar guidance systems detect home and other targets by sensing electromagnetic energy reflected from the surface of the target. A radar transmitter is the source of reflected radiation, and in the case of weapons with active radar guidance, you can see this transmitter located within the missile, and in some cases of semi-active guidance, it will be carried out by the launch of an aircraft. On the other hand, the transmitter must beam electromagnetic radiation at the target level, so that this radiation will travel to the target, reflect, and then travel back receiving the missile's antenna, be amplified, demodulated, and analysed to decide the course of the target, and with the help of this information, it enables the computer to guide the weapon towards the target to achieve a kill. [2] A successful weapon will be able to distinguish between the target's return and reflections from its background.

A wire-guided missile is a type of missile that is guided by signals transmitted to it via thin wires that connect the missile to its guidance mechanism, which is located near the launch site. These wires will be reeled out behind the missile as it flies. This system is most commonly used in anti-tank missiles, where it is useful in areas with limited line of sight. However, the longest range of wire guided missiles currently in use is around four kilometres. However, the Tube launched, optically tracked wire guided missile system (TOW) has a range of 3,750 metres and would be unlikely to be used at such a long range. [3]

MISSILE GUIDANCE:

Over the last four decades, guided missile systems have evolved at an incredible rate, and recent technological breakthroughs ensure that smart warheads will play an increasing role in maintaining our military superiority. On ethical grounds, one hopes that each warhead deployed during a sortie will only hit its intended target and that any misfire will not harm innocent civilians. From a tactical standpoint, our military wants weaponry that is dependable and effective, capable of inflicting maximum damage on legitimate military targets while ensuring our ability to launch lightning-fast strikes with pinpoint accuracy. All of these requirements can be met with the help of guided missile systems. [4] Missile guidance is the method by which a missile receives commands to move along a specific path in order to reach a target. These commands are generated internally by the missile computer autopilot on some missiles. Some external source transmits commands to the missile on others. The missile sensor, also known as the seeker, is a component within a missile that generates data that is fed into the missile computer. The computer processes this data and uses it to generate guidance commands. Infrared, radar, and global positioning systems are examples of common sensor types used today. [5] The computer autopilot sends commands to the control surfaces to adjust the missile's course based on the relative position of the missile and the target at any given point in flight.

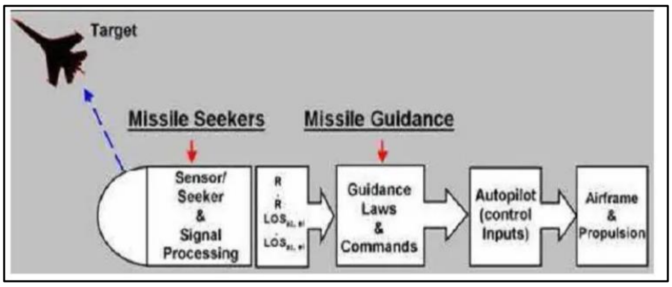

Fig. 1: Concept of missile guidance

Types of Missile Guidance

- Using Radar
  They send a radar signal that is reflected back from tanks and planes in the battle; these radar signals assist the missile in acquiring their targets, and the majority of them are successful.
- Using Wires
  They have a wire wound coil at the back of the missile, and when launched, they move in a linear direction to acquire targets. The gunman sends the necessary signals to the missile to acquire the targets, and if the wire breaks, the targets will never be achieved. They have no device in this missile.
- Using Laser
  These missiles are fired using a laser technique that searches for heat signatures. Once a heat signature is found, the target is acquired, and even if the target is moving, it is shot.
- Using GPS
  They use 3 axis accelerometer packages for autopilot reference. They are fire-and-forget weapons that do not require the launch aircraft to remain in close proximity to the target for guidance.

GPS

GPS, which stands for Global Positioning System, is the only system available today that can show us our exact location on the Earth at any time, in any weather, and from any location. A total of 24 GPS satellites orbit the Earth at 11,000 nautical miles above the surface. Ground stations around the world are constantly monitoring them.

The satellites send out signals that anyone with a GPS receiver can detect. You can pinpoint your exact location by using the receiver. GPS is divided into three segments: the space segment, the user segment, and the control segment. The space segment is made up of 24 satellites plus some spares, each in its own orbit 11,000 nautical miles above Earth. The user segment is made up of receivers that we can hold in our hands or mount in our vehicles. The control segment is made up of ground stations that ensure the satellites are operational. [6]

ADVANTAGES

- Timing and Range of Navigation System (NAVSTAR). The GPS can now be used in any weather, at any time, and from any location on or above the earth. The timing and ranging navigation system also provides precise time to the millionth of a second in order to synchronise the atomic clocks used in various military applications.
- GPS is even used to determine the current location of living and nonliving things; this is the well-known concept used in "GOOGLE EARTH."
- Military GPS has been integrated into user equipment such as fighters, bombers, tankers, helicopters, ships, submarines, tanks, jeeps, and soldier's gear.
- It is also included in the basic navigation activities for military applications, which include cruise missile and precision-guided weapon target designations, as well as close air support. [7]
- The government controls GPS receiver exports to prevent enemy GPS interception.
- GPS satellites can also contain nuclear detonation detectors.

ROLE OF SATELLITE IN MISSILE GUIDANCE

Satellite-guided weapons, such as JDAM (Joint Direct Attack Munitions), which use satellite navigation systems, specifically the GPS system, are not affected by the problem of poor visibility. This provides greater accuracy than laser systems and can operate in all weather conditions without the need for ground support. Because GPS can be jammed, the bomb reverts to inertial navigation if the GPS signal is lost. Inertial navigation is significantly less accurate; JDAM achieves a CEP of 13 m when guided by GPS, but only 30 m when guided by inertial. Furthermore, the inertial guidance CEP increases with decreasing altitude, whereas the GPS CEP does not. The precision of these weapons is determined by the precision of the measurement system used for location determination as well as the precision with which the target coordinates are set. [8] The latter is heavily reliant on intelligence information, not all of which is reliable. However, if the targeting information is correct, satellite-guided weapons are far more likely than any other type of precision guided munition to achieve a successful strike in any given weather condition.

MISSILE GUIDANCE USING GPS

The key concept behind designing GPS guided weapons is to use the 3-axis gyro/accelerometer package as a reference for the weapon's autopilot, and to correct the accumulated flow errors associated with the package using GPS PPS/P-code.

Such ammunitions are called 'accurate' because they provide CEPs (Circular Error Probability) of the order to check the accuracy of GPS P-code signals, which is typically around 40ft. The next step is to equip the weapon with a DGPS resulting position approximation before launch, allowing it to correct GPS errors as it flies to the target. These weapons are precisely designed and will produce more accurate results than laser guided weapons, which could have CEPs of several feet. [9]

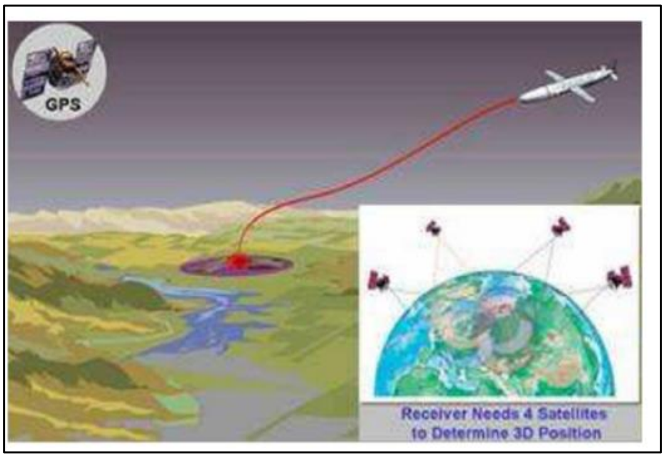

Fig. 2: Missile Guidance using GPS

The advancement of GPS is solely related to the development of guided munitions, which result in significant changes in how air warfare is conducted. A GPS weapon, unlike a laser-guided weapon, does not require a launch aircraft to remain in the vicinity of the target to light it up for guidance - GPS/related weapons are true fire-and-forget weapons. However, once these weapons are released, they will be completely autonomous and weather resistant, with no loss of accuracy; however, existing precise weapons require a covered line of sight between the weapon and the target for the optical guidance to work.

REVIEW OF LITERATURE

Gaudet et al. [10] pioneered the use of reinforcement learning in the design of two-dimensional homing-phase guidance laws. The DRL-based missile controller is more adaptable and efficient than traditional methods. Gaudet recently proposed meta-learning and reinforcement learning to solve the problem of angle-only intercept guidance of manoeuvring targets. In intercepting exo-atmospheric targets, the algorithm demonstrated remarkable robustness.

For intelligent missile guidance systems, including proportional navigation guidance, artificial neural networks are the preferred choice [11]. When compared to the use of active sensors, the use of video streams to obtain and locate targets has the potential to save money. This technique shows preliminary results for a system that uses visual sensing to locate and point the target [12]. To identify new objects or elements in a video steaming frame, the system employs foreground segmentation. Then it tries to determine their location in the real world using Speeded Up Robust Features (SURF) feature detection and a LAN-based IP camera module [13].

The system can now generate the altitude and position launch angles that will allow a toy missile to intercept the target based on the analysis of flight attributes for the toy rocket. By combining object determination and tracking into a dynamic Kalman model [14], a real-time state-of-the-art object determination and tracking technique from video stream frame images is developed. At the object detection stage, the object of interest is automatically detected from a saliency map processed using the image background cue at each frame; at the stalking stage, a Kalman filter is used to obtain a raw prediction about the object state, which is then re-processed using an on-board detector combined with the saliency map and sensual information obtained from the video steam [15].

OBJECTIVES

- To study rotary movements of a missile
- To study guidance phases of a missile
- To study missile Guidance using GPS
- To study role of satellite in missile guidance

RESEARCH METHODOLOGY

A research methodology is a method for solving a research problem in a systematic manner. It can be thought of as a science that studies how scientific research is conducted. In it, we look at the various steps that a researcher takes when studying a research problem, as well as the logic behind them. The researcher must understand not only the research methods/techniques but also the methodology. A close reading and detailed analysis of secondary sources is required in order to apply the analytical and descriptive methods to the research. It is critical to obtain additional perspectives in order to expand on the textual analysis, which would necessitate close reading analysis of a few secondary materials.

RESULT AND DISCUSSION

Under complicated conditions such as target manoeuvre, measurement noise, and detection delay, the modern missile is expected to cause the most damage to the target. As shown in Fig. 3, the missile should hit the target from the front, which means the terminal intercept angle and terminal missile velocity should be as large as possible. These requirements make missile guidance a difficult problem. [16]

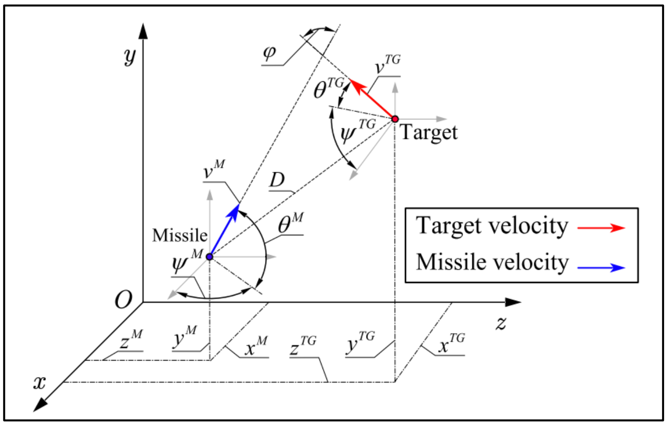

Figure 3: depicts an example of missile guidance engagement geometry. The intercept angle of the missile should be as large as possible when it intercepts the target.

Guidance is a feature of a missile system that assists it in determining the direction in which the missile should move. In general, this decision must be made at very short intervals of time (1/50th of a second) during the missile's flight. Some missiles require more than one guidance system. [17] The requirement is determined by the stage of guidance. The guidance phase of many missiles is divided into three stages: The three phases are the boost/launch phase, the mid-course phase, and the terminal phase.

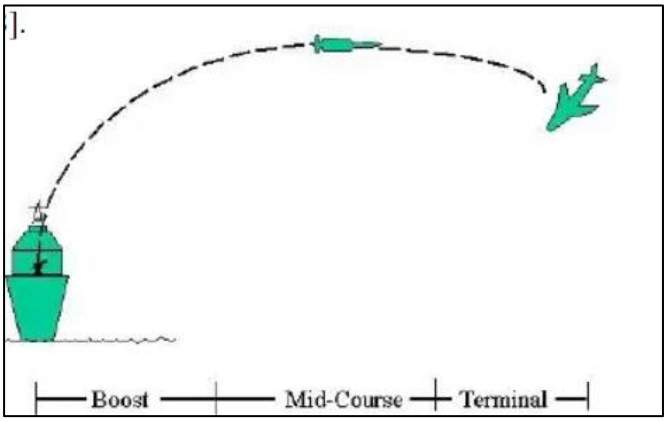

Fig. 4: Guidance phases of a missile

The missile's motion as a free body. A guided missile, like any moving body, performs two basic types of motion: rotation and translation. All parts of the missile pivot around the centre of gravity in pure rotation. The centre of gravity moves along a line in translational or linear motions. The missile has six degrees of freedom or dimensions of freedom in total (movement). We use a reference system of lines or axes to describe these motions. These axes cross at the centre of gravity of the missile. Three of the missile's six degrees of movement are translational or linear about three axes, namely x, y, and z, while the other degrees are rotational movement about three axes, namely pitch, yaw, and roll[18].

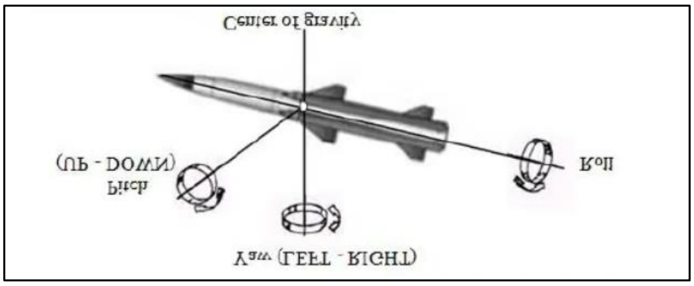

Fig. 5: Rotary movements of a missile: pitch, roll, and yaw

CONCLUSION

GPS guided weapons are not affected by bad weather, are not restricted by a wire, and do not expose the gunner to attack. With technological advancements over previous generations, GPS guided weapons are the superior weapon of choice in modern warfare. Missile Guidance that is Adaptive Using GPS is the most efficient method of pursuing any target because it saves economic losses, environmental losses, and a variety of other losses that were experienced during early wars. Missile guidance is the method by which a missile receives commands to move along a specific path in order to reach a target. These commands are generated internally by the missile computer autopilot on some missiles. On others, the commands are sent to the missile by an outside source.

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