Term Paper

on

Military's Use of Artificial Intelligence in Automatic Target Recognition

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by

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DECLERATION

I, Shaurya Guliani, student of B.Tech (2CSE-2X) hereby declare that the project titled "**Military's Use of Artificial Intelligence in Automatic Target Recognition**" which is submitted by me to Department of Computer Science and Engineering, **Amity School of Engineering Technology**, Amity University Uttar Pradesh, Noida, in partial fulfillment of requirement for the award of the degree of Bachelor of Technology in Computer Science and Engineering, has not been previously formed the basis for the award of any degree, diploma or other similar title or recognition.

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CERTIFICATE

On the basis of declaration submitted by **Shaurya Guliani**, student of **B.Tech CSE,** I hereby certify that the project titled **"Military's Use of Artificial Intelligence in Automatic Target Recognition"** which is submitted to Department of Computer Science and Engineering, Amity School of Engineering and Technology, Amity University Uttar Pradesh, Noida, in partial fulfilment of the requirement for the award of the degree of Bachelor of Technology in Computer Science and Engineering, is an original contribution with existing knowledge and faithful record of work carried out by them under my guidance and supervision.

To the best of my knowledge this work has not been submitted in part or full for any Degree or Diploma to this University or elsewhere.

Place: Noida

Date:

Dr. Manoj Kumar Shukla
Department of Computer Science & Engineering
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Amity School of Engineering & Technology, Noida

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CONTENTS

ABSTRACT

This paper illustrates the functioning of "**Visual Based Automatic Target Recognition systems**" by Military which uses camera sensors and Artificial Intelligence Programming Languages like C++ and Python to scan an area for potential targets and recognize them and explains the framework and algorithm used for the development of software used in these systems.

The above mentioned Computer Vision based target recognition systems solves the problem of detection of moving targets which RADARs were unable to and are able to process more than one targets at a time. Also, because of the presence of visual sensors, more information about the unknown body can be drawn out.

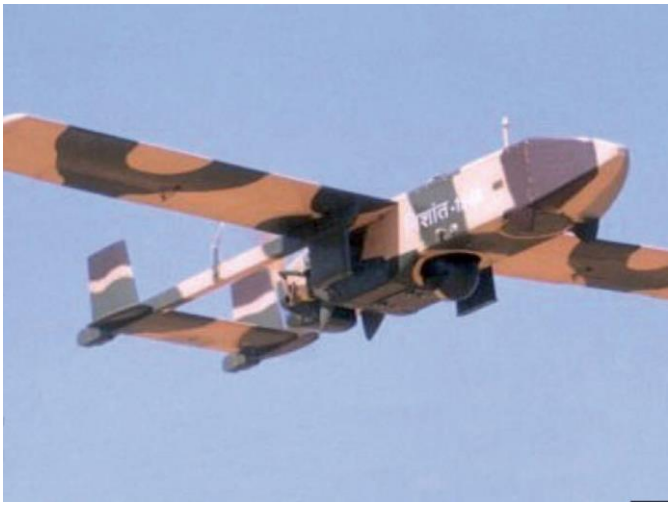
Automatic Target Recognition as practiced by the Military is divided into two parts: "Target Detection" and "Target Recognition". Target Detection is scanning a particular area for the presence of hostile targets such as enemy vehicles and defence systems. This is done by using camera sensors which passes visual frames through the target detection program and examines the frames for potential targets. Target Recognition is the process of looking for the obtained visual targets in a specified database which would provide us with additional important information about them. This paper will explain how these functions are carried out using knowledge of Artificial Intelligence and Computer Vision.

INTRODUCTION

Automatic Target Recognition (ATR) refers to the technique of recognition of specified targets based on sensor obtained data.

The primary aim of an Automatic Target Recognition (ATR) system is to detect and recognize unfamiliar bodies in a frame of view which may or may not be hostile. These systems have proved to be very helpful for the defence agencies of many countries as these helped them to stay steps ahead of the enemy at difficult times.

This technique is used by Military as target detectors in many areas, such as in Unmanned Aerial Vehicles (UAVs) and Unmanned Ground Vehicles (UGVs) for detection of targets in a small specified area and in Satellites for detection in large areas. It is also used in IFF Transponders. As this system is automatic, it reduces the man power required for the functioning of tactical aircraft crews and assisting the on-foot soldiers by providing them information about the approaching threats. Because of its ability to detect targets, it helped in the creation of first generation of guided ammunition (guided missiles) which locks-on to the specified target and follows it until impact. This increases the effectiveness of the missile and decreases the collateral damage.



DRDO Nishant (Indian UAV)

DRDO Muntra (Indian UGV)

“Radar defeated the axis” said the British Prime Minister Winston Churchill in 1945 after the conclusion of World War II as Target Recognition systems (then commonly named radars) solved the problem of inability to sense incoming of aerial bomber planes which played an important role in World War I.

The new generation of Automatic Target Recognition systems uses computer vision for detection and recognition. The introduction of Artificial Intelligence in ATR systems resulted in the development of the new age target recognition systems which are more accurate and uses visual camera based information and thus, are known as Visual Based Automatic Target Recognition systems.

This paper aims on providing the framework along with the programming used to develop the AI software which is installed in Visual Based Target Recognition systems which uses Haar-like characteristics and Barcode matching for visual detection and recognition.

The paper is organized into 4 sections:

I. First section “Literature Review “gives a brief history about the first target recognition systems (radars) and a small introduction about Computer Vision.
II. Second section “Methodology for Visual Based Target Recognition System” explains the framework used for the Camera Based Target recognition system and how target detection and recognition is carried out.
III. Third section “Programming with Open CV” talks about the use of Open CV libraries and how they are useful for carrying out computer vision programming.

I

LITERATURE REVIEW

The initial Target Recognition showcased the use of the received signal's audible representation which required a trained person to decipher these sounds and classify the radar's illuminated targets. These methods were successful but to make these processes more accurate and faster, the target recognition systems needed to be automated and hence, Automatic Target Recognition Systems were made which were able to function without the need of a trained operator. [1]

The first known major Military use of the above explained radar based target recognition system dates back to mid-20th century during World War II. Only **Great Britain** and **Germany** were the nations which had fully functioning radars for detection at the time of declaration of war in 1939. The **United States** had the radar technology since before the start of the war but they recognized its true potential as a detecting system in 1940 only and started using them on their ships. By the end of the war in 1945, **The Soviet Union**, **Japan**, **Italy**, **France** and **Sweden** along with commonwealth nations like **Australia**, **Canada**, **New Zealand** and **South Africa has Radars**. [2]

German radars which were used to detect incoming aircrafts during World War II

The former Prime Minister of the United Kingdom said that radars played a very important role in the victory against the Axis (Japan, Germany and Italy) in World War 2. However good these radars were at that time, they evolved over the years and still are changing to become faster and more efficient.

Artificial Intelligence is a concept which changed the way of functioning of a target recognition system. It not only made it automatic but also gave it the abilities to analyse targets just like a professionally trained person. Coding languages like C++ and Python helped in the creation of frameworks to scan an image (frames, in video format) to look for objects of a particular species (humans, cars, aeroplanes) as specified in the programming. The programs made by using these frameworks are called object detection programs. [3]

Detection of airplanes in satellite images using object detection program

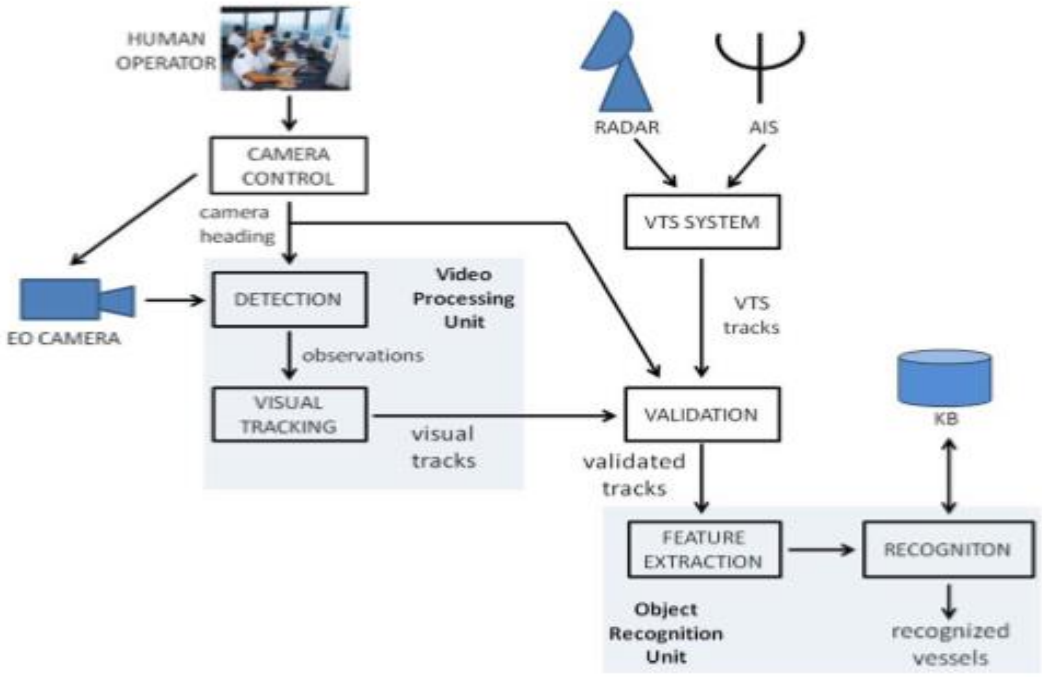
The above described process of object detection using image scanning comes under the field of Computer Vision which deals with ways for computers to access high-level information from photographic images or digital videos. [4]

The first idea of Computer Vision dates back to late 1960s where it first started in Universities which were exploring Artificial Intelligence. Its primary aim was to impersonate visual system of the human eye to move a step closer to the development of intellectual functioning of robots. Foundations of many of the existing frameworks like photo-edge extraction and line labelling in modern Computer Vision are a result of studies made in the 1970s.[5]

Over the years Computer Vision evolved itself and made its way in Military operations where it plays a very vital role in both defence and offence system. Whether it is to warn the base about an incoming hostile threat or recognizing particular targets in an area, all is made easier with the help of Computer vision.

II

METHODOLOGY FOR A VISUAL BASED TARGET RECOGNITION SYSTEM



Camera Based Automatic target Recognition System algorithm as used by Vessel Traffic Service (VTS)

The main sensor which is used in this system for photographic processing is the Electro-Optical (EO) Camera. The cameras are rotatable and can look around in any direction and process images while moving. However, the speed of rotation should not be too much as that would create a highly dynamical background for the camera. There is a Video Processing Unit installed which is used for detection purposes. [6]

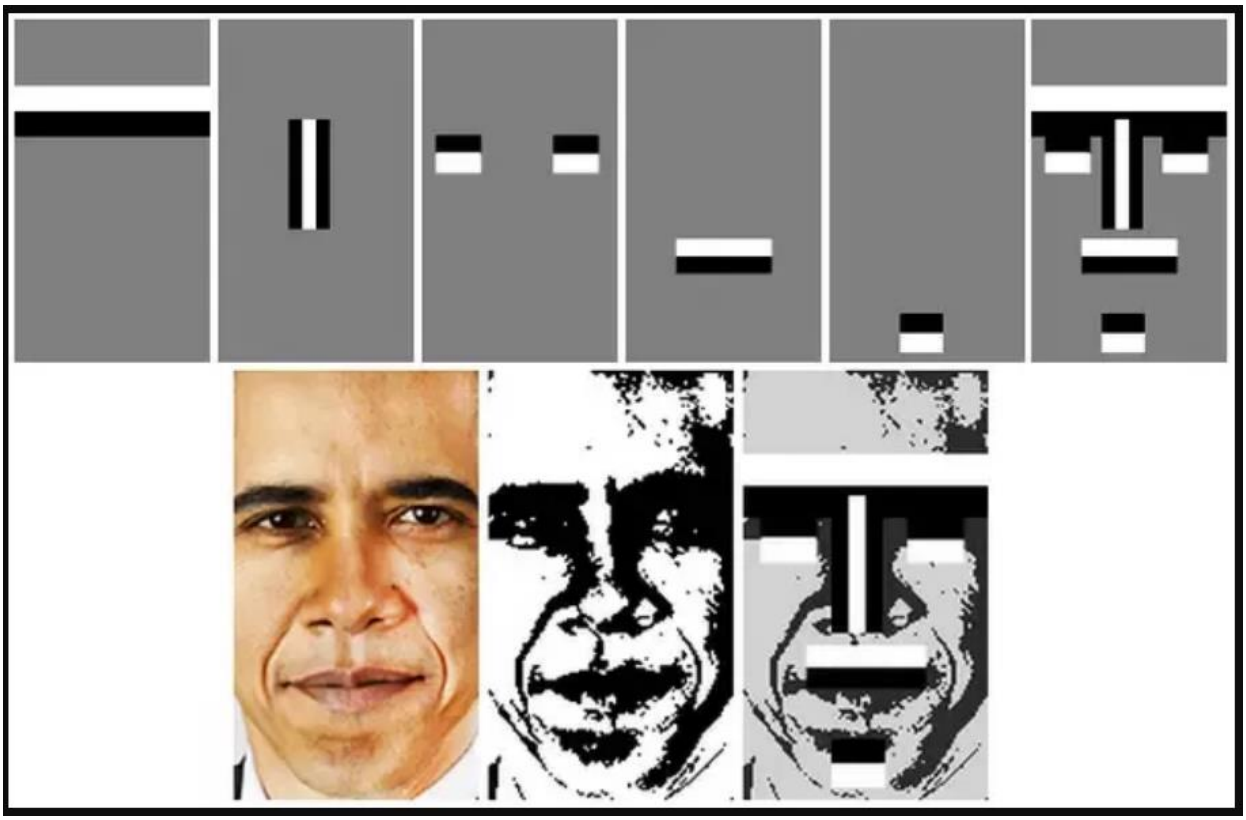
The framework for spotting and identification of targets is divided into two modules:

1. Target detection
2. Target Recognition

TARGET DETECTION

The work of the Target detection module as the name suggests is to look for potential targets in continuous video frames. Everything which gets captured in the EO camera is sent to the video processing unit where its scanning is done for detection of targets. There are numerous ways of separating particular species of objects (like human faces, cars) from a big picture. However, in this particular system a classifier based approach is used. [6]

Haar-like characteristics are a set of features which were used to create the classifier which was used in the first face identifier. [7] The same features are used in the creation of the classifier for this system with some programming modifications to make the classifier detect other objects like hostile aircrafts and UAVs. One of the main reasons to use these features for the classifier is that it provides it with the required functions at a substantially low price.



Haar-like features used for face detection

After the detection of frames is done, a list of targets which were observed along with the frames with boxes around those objects are obtained which can be sent to the recognition system for identification. [6]

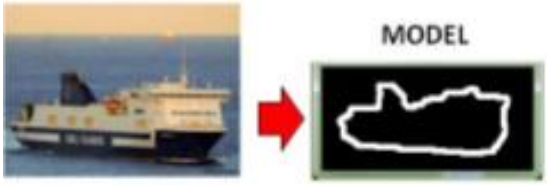
TARGET RECOGNITION

Once the target is obtained, it is the work of the target recognition module to notify the base with other important information about the target and whether it is of hostile origin or not. It can help to identify what exactly the object is and can even supply with information about the external physical attachments installed to that object including defence systems like radars, explosives etc. this is done by looking for the observed object in a vast database. [7]

The algorithm adopted for this work is the "Barcode Matching" algorithm because of its ability to function with low definition images. The algorithm is used for target recognition in the following steps:

i. The classifier is used to obtain a box around the detected target.

ii. The object's outline is obtained by withdrawing the edges of the object inside the box and unnecessary background images are filtered.



iii. The outline obtained is resized to match the sizes of the pre-stored objects present in the database. This is a very important step as in absence of this, the consecutive steps won't function.

iv. A histogram is obtained using the outline in which each bin value of the histogram is the distance between the outline and the top of the image.

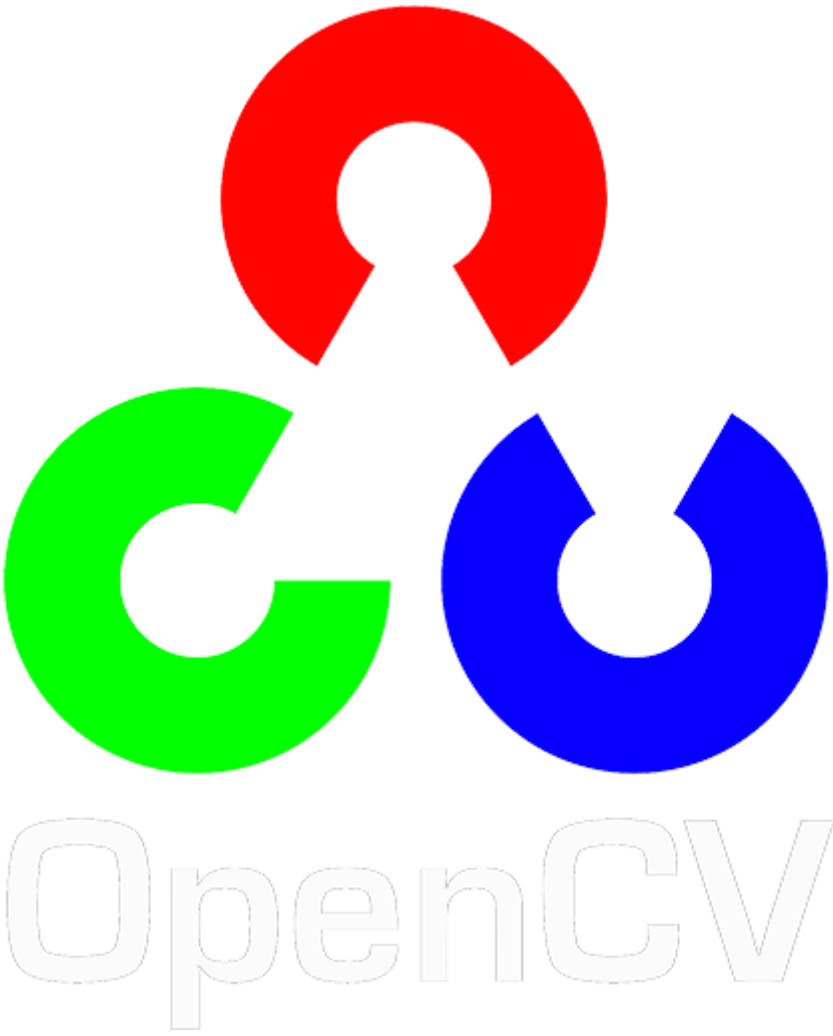
v. Similarly, a loop is run in which the histogram obtained is compared with the histograms of the pre-stored objects in the database and the result is obtained whenever a match is found. [7]

The comparison is done using the Bhattacharya distance, a quantity used to measure difference between two statistical distributions. The lesser is the Bhattacharya distance is, the more similar the target and the pre-stored object are. [7]

III

PROGRAMMIN WITH OPEN CV

The framework explained in the above section needs to be embedded in a program for which coding languages like Python or C++ is used. However, there are many languages which can be used for programming purposes; Python and C++ are considered the best for computer vision applications in Artificial Intelligence. As time is passing by, more and more new models of visual target recognition frameworks are coming up, sometimes, using the same programming algorithm. Hence, to save the time of again and again writing down the same lengthy programmes, "**Open CV**" libraries are used.



Open CV stands for "Open source Computer Vision". It is a library of algorithms which are pre-defined ready to use mainly for computer vision applications like object detection, face detection, people/vehicle counting, biometric recognition etc. Open CV has made it easier for the new AI recognition systems to adopt previous models frameworks. The adopted frameworks can be used unchanged or with minor modifications hence, saving the time to make a similar code again. Open CV was created using C++ and can be used with many languages like Java, MATLAB, C++, Python. [8]

Python is considered the best language for using with Open CV for creation of programmes based on target detection:

i. Python is supported with dictionary
ii. Simple OOPs (Object Oriented Programming system)
iii. Python has an open and a free source
iv. It is easily readable and programmable
v. Zero-based numbering is used in python
vi. Python's one module can be embedded with many functions [8]

CONCLUSION

An Automatic Target Recognition (ATR) System is an arrangement which is used to detect and recognize specific targets. ATR systems are used by the military to find unknown targets in specific areas and to recognize what they are and draw information about them.

The first kind of Target Recognition systems (RADARs) used audible representations for detection purposes. However, the new generation of such systems started operating on techniques of Artificial Intelligence (Language Programming and Computer Vision) for visual detection and recognition which comparatively gave faster and more accurate results.

The Visual Based Target Recognition System can use modified Haar-like Characteristics and Histogram Barcode Matching for the detection and recognition processes respectively. Haar-like characteristics were the features used for the creation of the first Visual Face Detector which were modified to detect specific objects according to the programming. For the recognition, object outlines and the Bhattacharya distances between the top of the image and outlines are used for the creation of histograms for comparison with histograms of sample objects which are pre-stored in the database.

Open CV libraries are collections of algorithms mainly dealing with Computer Vision programming and has helped a lot in the easy creation of better Visual Target Recognition systems which used the same or similar types of image processing algorithms as used in older systems providing a scope for making improvements in existing systems.

Artificial Intelligence and Computer Vision has helped in the evolution of Automatic Target Recognition system by enabling them locate targets with greater efficiency and accuracy thereby, strengthening the defence systems of countries.

FUTURE SCOPE

Artificial Intelligence is a vast field and a major part of it is yet to be discovered. There are a lot of technologies which are yet to be discovered, not only for the evolution of Automatic Target Recognition but also for other important military operations.

No Target Recognition System is exactly flawless. The aim is to assemble one which can be economical and have disadvantages which could be ignored at the time of functioning. Hence, a number of better technologies are yet to come which will make recognition systems more and more accurate and easy to function

Talking about Artificial Intelligence in other sectors of military, we might even see the participation of humanoids in real time defence situations if ever need be in the future, but that will take time as it is a difficult process to implement due to the risk factor of giving such a big responsibility to a programmed android.

The knowledge of Artificial Intelligence and computer vision has proved very useful to provide reliable intelligence to the military and newer systems are yet to be created which will help in enhancing the defence sectors of countries. The modern times require the aid of computers and AI and hence, all the nations are trying to make the best use of them everywhere possible.

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