Stealth Aircraft Detection By Using Thermal Image And Laplacian Of Gaussian Algorithm

Authors
Sagar Shankarrao Dake¹, Hemanta Kumar Mohanta², Sushma Yadav³
¹M.Tech (IT), ²M.Tech (CST), ³M.Tech (IT)

Email- Sagar.dake980@gmail.com¹, hkmohanta1986@hotmail.com², sushmayadav1249@gmail.com³

ABSTRACT
From the last few years, stealth technology is used in aircraft, ships, submarine etc. stealth aircraft are consider as invisible aircraft, which are dominate the skies. In this paper, stealth aircraft will detect by using Thermal Image and Laplacian of Gaussian algorithm. The thermal image will detect the aircraft engine heat and then the laplacian of gaussian algorithm will detect the edges of that aircraft, then it will easily identify. In this paper, 2D OTSU algorithm is used in thermal imaging, aircraft position prediction is also used for detect the aircraft position and then finally laplacian of gaussian algorithm is used.

Keywords- 2D OTSU Algorithm, position prediction, 3D edge detection.

INTRODUCTION
Stealth technology also termed LO technology (low observable technology) is a sub-discipline of military tactics and passive electronic countermeasures, which cover a range of techniques used with personnel, aircraft, ships, submarines, missiles and satellites to make them less visible (ideally invisible) to radar, infrared, sonar and other detection methods. Stealth is one of the most misunderstood and misinterpreted concepts in military aviation by the common man. Stealth aircraft are considered as invisible aircraft, which dominate the skies. With an additional boost from Hollywood action movies, stealth is today termed as the concept invincibility rather than invisibility. Though, the debate still continues on whether stealth technology can make an aircraft invincible it was found that stealth aircraft are detectable by radar. [1] The motive behind incorporating stealth technology in an aircraft is not just to avoid missiles being fired at is but also to give total deniability to covert operations. This is very much useful to strike targets where it is impossible to reach. In this paper, the stealth aircraft will be easily detected by using thermal imaging and Laplacian algorithm. The general design of a stealth aircraft is always aimed at reducing radar and thermal detection. One of the possible definitions is as follow: stealth technology minimizes the observable aspect of a piece of military equipment, including radar and infrared signature, visibility and sound. Stealth technology is used to make military equipment more difficult to detect, track, identify and engage by defensive weapon system. Signature control or stealth is nothing new to aircraft, armies and navies. In this paper first of all aircraft engine heat detects by thermal imaging and after that for edge detection laplacian of gaussian algorithm is used. Stealth Technology in aircraft: Continuous developing in military ships technology by stealth technology have produce a new sort of defensive weapon. Stealth ships can easily invisible into enemy, drop a payload and come back out without being detected, identified or attacked. To get these goals, the stealth in many ways: [2]
1) It must be very hard to detect on radar
2) Its engine should not produce heat or smoke
3) It must be quite.
4) It should be very hard to see with human eye.

2 RELATED WORKS

2.1 Thermal image:
2.1.1 Image Segmentation: The image segmentation is the process of partitioning a digital image into multiple segments. Segmentation is the key and the first step to automatic target detection, which will directly affect. The goal of segmentation is to simplify or change the representation of an image into something that is more meaningful and easier to analyze. [3] Infrared heat wave image is different from the visible light images. It reflects the distribution of the object surface temperature and latent characteristics of material form.

2.2 2D OTSU Algorithm: [3]
The two-dimensional Otsu algorithm is given as follows. Suppose an image pixel size is \( M \times N \), gray-scale of the image ranges from 0 to \( L-1 \). The neighbourhood average gray \( g(m, n) \) of the coordinate definition \((m, n)\) pixel point is as follows:

\[
g(m, n) = \frac{1}{k \times k} \sum_{i=-(k-1)/2}^{(k-1)/2} \sum_{j=-((k-1)/2)}^{(k-1)/2} f(m + i, n + j)
\]

Calculating the average neighborhood gray of each pixel point, a gray binary group \((i, j)\) may form. We use \( C_{ij} \) to represent the occurrence frequency of \((i, j)\). Then the probability \( P_{ij} \) of vector \((i, j)\) may be determined by the formula:

\[
P_{ij} = \frac{C_{ij}}{MN}
\]

Here, \( 0 \leq i, j \leq L \text{ and } \sum_{i=0}^{L-1} \sum_{j=0}^{L-1} P_{ij} = 1 \)

Assuming the existence of two classes \( C_0 \) and \( C_1 \) in two-dimensional forms, the histogram represents their respective goals and background, and with two different probability density distribution function. If making use of two-dimensional histogram threshold vector \((s, t)\) to segment the image (of which \( 0 \leq s, t \leq L \)), then the probability of two classes are respectively: The probability of background occurrence is:

\[
\omega_0 = P(C_0) = \sum_{i=0}^{L-1} \sum_{j=0}^{L-1} P_{ij} = \omega_0(s, t)
\]

The probability of object occurrence is:

\[
\omega_0 = P(C_1) = \sum_{i=s+1}^{L-1} \sum_{j=t+1}^{L-1} P_{ij} = \omega_1(s, t)
\]

The definition of dispersion matrix:

\[
\sigma^2 = \omega_0[(\mu_0 - \mu_0)(\mu_0 - \mu_0) + \omega_1(\mu_1 - \mu_1)(\mu_1 - \mu_1)]
\]

When the track of the above-mentioned dispersion matrix gets the maximum, the corresponding threshold of segmentation is the optimal threshold \((S, T)\), namely:

\[
\text{tr}(\sigma^2(S, T)) = \max_{(s,t)\in\Omega} \{\text{tr}(\sigma^2(S, T))\}
\]

We know that 2-D thermal images with noise segmented by Otsu way may get better results compared to one
dimensional threshold segmentation methods. However, the computation cost gets huge, which is because the determination of the optimal threshold need to travel all the s and t, of which 0 ≤ s, t < L. The segmentation result it’s optimized by number of method and identification of target. This segmentation is used in fused image target tracking. The optimum threshold will be determined by using histogram analysis. The chaos based genetic algorithm make the process time lower. The chaos based genetic algorithm uses otsu algorithm as fitness function and proceed for segmentation. From the mathematical sense it is possible to predict the long-term behavior of the system, even know its past function and state by the power system. Chaos has regularity, ergodicith, random city based on these characteristics of chaos, using chaotic variable to optimize search there is no doubt better than random search. Logistic map is the basic chaotic map. The chaos equation of the logistic definition can be described as:

\[ x_{n+1} = u \times x_n (1 - x_n) ; \quad 0 < u \leq 4 \]

### 2.3 Aircraft position prediction [4]

The accurate prediction leads the tracking system to desire stability. The position prediction is based on gray theory, it assumes the parameter internal structure and characteristic of observed system that are unknown, or else it is called “black system”. The sensory information can measure external performance of system and it find a suitable model to approximate its dynamic. The approximate model is also called the “white system”. The optimal parameter of white system is calculated from so-called “grey model”. The grey model is written as GM (α,β) where, β is number of variable equation and α is order. In the implementation stage β variable differential equation and α is the modeling equation. The higher the assigned α, the more sensitive to the input data will the obtained model become. The GM(1,1) is widely used and in application its successfully demonstrate such as forecasting, earthquake prediction. The Time-varying scalar is used for tracking a moving target, from the sensory information should be x(t) where (t=1,2,…,n) and the accumulated generating operation is define as accumulated measurement \( z(k) = \sum_{t=1}^{k} x(t) \) for (k=1,2,…,n). We then model the dynamic change of \( z(t) \) by the following first-order ordinary differential equation

\[
\frac{dx(t)}{dt} + a \cdot x(t) = b \quad (1)
\]

In grey theory, (1) is called the “white descriptor” for modelling a white system and we can estimate parameters a and b from the observed system outputs. However, to estimate the parameters of the unknown system only from the sensory measurements it is approximated by the following grey-differential equation.

\[
\frac{dg(t)}{dt} + \alpha g(t) = b \quad \text{where} \quad g(t) = (x(t + 1) + x(t))/2 \quad (2)
\]

To estimate the optimal parameters a and b, the minimum least-square method can be applied by introducing the accumulated generating operation in a time interval. For simplification purposes, the sampled time of past measurement X is taken as a unit. The first term of (2) in a discrete system can be written as

\[
\frac{dx(t)}{dt} = z(t + 1) - x(t) = x(t + 1) \quad (3)
\]

Equation (2) can be rewritten as

\[
x(t+1) = x(t) + b \quad (4)
\]

Substituting the sequential data X and Z into (4), we get the following matrix relation.
Equation (5) can be rewritten as

\[ Y = [x(2), x(3), \ldots, x(n)]^T B \phi \]  

(6)

Where B is as shown at the bottom of the page and

\[ \phi = [a, b]^T \]

For the case of \( n \geq 2 \), we can apply ordinary least-square estimation with a linear model \( Y = B \phi \), where the sum of squares function is defined by the following quadratic equation

\[ \zeta L S = (Y - B\phi)^T (Y - B\phi) \]  

(7)

The optimal solution can be obtained by minimizing the \( Z' \); using the matrix derivation \( \nabla \) with respect to \( \phi \) as the following equations:

\[ \nabla \phi L S = 2[V_\phi (Y - B\phi)^T][Y - B\phi] \]  

(8)

\[ V_\phi (Y - B\phi)^T = -V_\phi \phi^T B^T = -B^T \]  

(9)

Setting (8) to zero, the optimal parameters of \( \phi \) the grey model can be obtained by the following equation

\[ \hat{\phi} = [a \ b]^T = (B^TB)^{-1}B^TY \]  

(10)

The estimated parameters are then brought into the response solution of the first-order ordinary differential equation (1) for prediction of the accumulated generating operation

\[ \hat{z}(n+1) = (\hat{z}(1) - \frac{\hat{a}}{\hat{b}}) e^{-\frac{\hat{b}}{\hat{a}}} \frac{\hat{n}}{\hat{a}} + \frac{\hat{b}}{\hat{a}} \]  

(11)

**Figure 1.** Aircraft thermal image.

### 3. PROPOSED WORK

#### 3.1. A 3D edge detection scheme

#### 3.2. Filtering stage

Choice of 1D smoothing operator: \( T(X) \)

We strongly recommend to choose a filter that can be implemented recursively, mainly because of the computing time. We can for example choose one of two filters: \( T_1 \) or \( T_2 \).
Theoretically the derivation filter \( T_1(x) \) is better than Canny's multiple response criterion, but \( T_2(x) \) meets the best trade-off detection location. For small value \( T_2(x) \) induce some delocalization problem. This drawback will be share to any filter whose impulse response is at point 0. Or else the results do not different on many kinds of image.

### 3.3 Choice of the kind of approach

Generally the second derivative of the computation is more sensible to noise. At second side the computational cost is lower, because of the simplification will occurs when the computing impulse will filter by addition of smoothing and multiplication and second derivative operator. The noisy images are useful to threshold zero crossing provided by filtering stage, and at each zero crossing stage it require to compute the gradient magnitude. The location of edges provided by two kind of method is experimentally the same. The laplacian approach it may be point out to the smooth right angle.

Let \( I(X_1,\ldots,X_n) \) image dimension \( n \).

Let \( G(X_1,\ldots,X_n) \) Gradient of \( I \)

\[
G(i) = \left( \frac{\partial I}{\partial x_1},\ldots,\frac{\partial I}{\partial x_n} \right)
\]

The computation of the gradient component is done by computing image \( (\partial_i) \) corresponding to the partial derivatives with respect to \( x_i \) as follow.

**Step 1:** In this paper, the stealth aircraft will detected by using thermal imaging and then laplacian of Gaussian algorithm. The first stage is that the satellite or camera will take a photo (2D or 3D) then if in that image if it is noise image then image noise reduction process will start.

**Step 2:** The thermal imaging are used to detect the engine heat by using 2D OTSU algorithm, then laplacian of gaussian algorithm will apply and it will detect the aircraft edges, finally it will easily identify, and it will check if this is normal plane or stealth aircraft.

**CONCLUSION**

The proposed work is described to detect the stealth aircraft by using thermal image and laplacian of gaussian algorithm. The position prediction will show the exact position of that aircraft and 3D edge detection is used to detect the 3D photo edges.
REFERENCES


2. Zrínyi Miklós National Defence University, Electronic Warfare Department, Budapest, Hungary “Stealth technology deployed on the battlefield”.


4. Ren C. Luo, Fellow, IEEE, and Tse Min Chen, “Autonomous Mobile Target Tracking System Based on Grey-Fuzzy Control Algorithm”.

Sagar Shankarrao dake et al IJSRE Volume 3 Issue 12 December 2015