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Drone As Bomb Detectors

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ABSTRACT:

With drone technology being competent on all aspects from aerial photography to target attacks, it promises the human kind to aid in every possible manner. The heights are been the backlog of human to act actively on. Drone's dedicated applications to solve the human's impossibilities of achieving higher altitudes all in the sudden, are definitely productive. From technical to luring hobbyist can enjoy the ease of handling these quad copters. When these UAVs are used for the security and surveillance purpose that takes part in target killing and target attacks that go against terrorism and reducing the risks of explosives too. The drones with installed IR cameras are used to inspect the crowed areas in order to suspect the traces of explosives. These traces are detected using image classification that learns from the pixels of the images about the abnormalities in the temperature. The trained model deployed into the drone software is capable of predicting and detecting the explosive's presence from its legal altitude. The controller would beshared with the location of abnormal spot to take necessaryactions.

KEY WORDS: Explosives, drone theory, GPS module,CNN model

INTRODUCTION

Recent advances in infrared (IR) thermal sensing and Unmanned aerial vehicle (UAV) got much concentration recent years becauseof it is numerous applications. Drone can beused as an

Additional base station to overcome the surge in data traffic demands. Moreover, drones can be located during calamity to provide on-demand wireless coverage by enabling multi-hop communications. Drones have a wide range of applications in tracking, transportationmonitoring,aerial photography and device-to-device(D2D) software system for communications between devices, disaster relief, location- based services operations, data rate enhancement, and security provisioning etc.

The application of thermography on buildings is already well-known practice, as thermography enables us to distinguish the surfaces with different temperatures. IR cameras located on planes can be used for large-scale airborne temperature mapping to document temperature signatures on the scale of whole suburbs at once. However, drones deployment can consciously or accidently violate the security measures of the National institutions. It can act as a carrier for transferring explosive payloads and also violate the boundary of security sensitive areas. These violations might be launched from any illegal organization including non- certified, extremist, and terrorist or from any private operators carrying chemical and other explosive materials. The use of bomb detecting drones for detecting. Explosives which ultimately decreases the public safety threats. However, due to drones small size, capability to fly at low altitudes, and their low radar cross section, they can easily enters in no fly zone area .However, each schemes has its benefitsand limitations.

Motivated by this, we presented a convolutional neural network(CNN)in deep learning, a convolutional neural network is acategory of deep neural networks, most commonly applied to analyzing visual imagery inspired IR image based drone detection scheme that can quickly achieve higher accuracy with less complexity even in crowded environment. The image Fig 1.1 shows the IR image of different explosives.

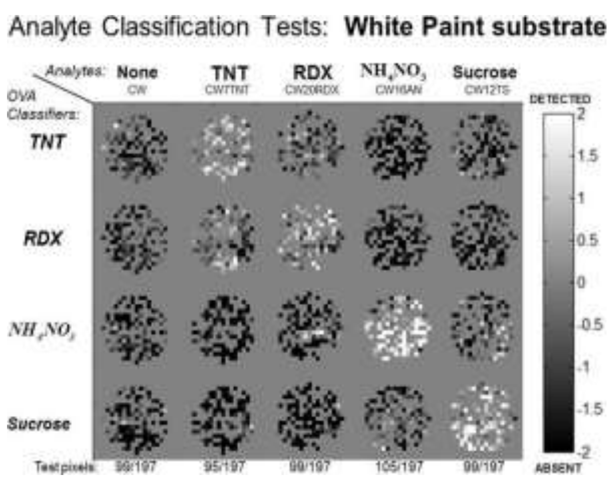


Fig 1.1

The proposed scheme integrates the advanced thermography processing and CNN algorithms to enhance the IR detection performance. IR cameras installed drones with GPS module embedded, that shares the exact location of the explosive that is suspected (heat variation traced by IR cameras) where it over comes the disadvantages of the existing system. The existing system uses RADAR technology to detect the explosives. The electromagnetic waves used can be controlled from 15kms away , where other range of electromagnetic waves can interfere and can cease the accuracy. This raises the issue in accuracy and false detection.

I. EXISTING SYSTEM

The existing system uses RADAR technology to detect the explosives. The electromagnetic waves used can be controlled from 15km away, where other range of electromagnetic waves can interfere and can cease the accuracy. This raises the issue in accuracy and false detection**.**

Suicide bombers and act of handling explosives for massive attack are the common form of terrorism and insane act against human kind in the name of hatred. Human bomb-squads, explosive detecting devices, dog bomb-squads are the traditional techniques to trace an explosive since 1880's.

NEGATIVITY: Risking lives for explosive detection (one life is also valuable).

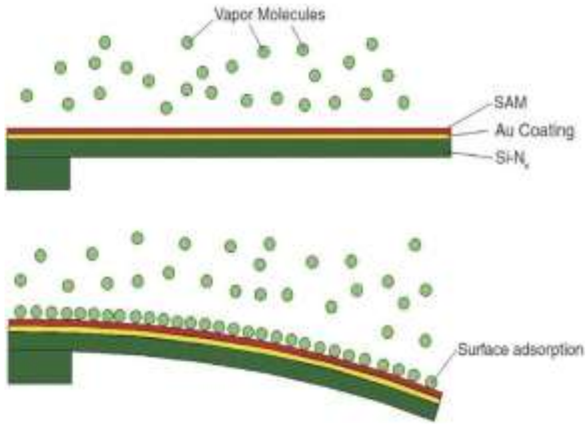
II. PROPOSED SYSTEM

IR cameras installed drones with GPS module embedded, that shares the exact location of the explosive that is suspected (heat variation traced by IR cameras). The examples of the type of explosives will be trained by using CNN (**C**onvolutional **N**eural **N**etwork) because it is the effective way to have accurate results.

- **WHY IR CAMERAS?**

More recent non-contact approaches have been based on optical spectroscopies (such as laser-induced breakdown), but those typically use visible or UV lasers, which are not safe for our eyes. Non-contact or 'standoff' detection of explosives techniques, where evaporation is slow and insufficient vapour is left in the air for 'sniffing' technologies.

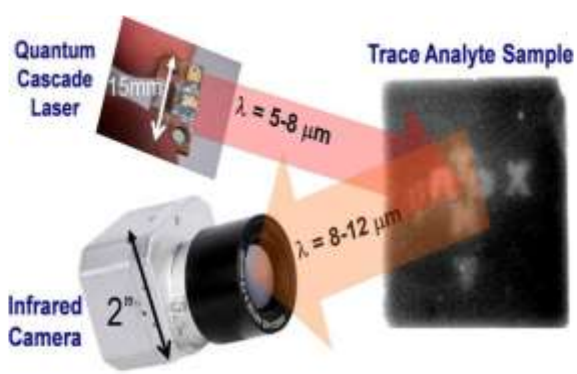
IR spectroscopy is based on the well-known absorption type properties that are intrinsic to the specific chemical bonds within a molecule. 'Puffer' (designed to blow particles off surfaces and collect them) were abandoned because they collected too much interfering dust.



● IR CAMERAS IN IR SPECTROSCOPY:

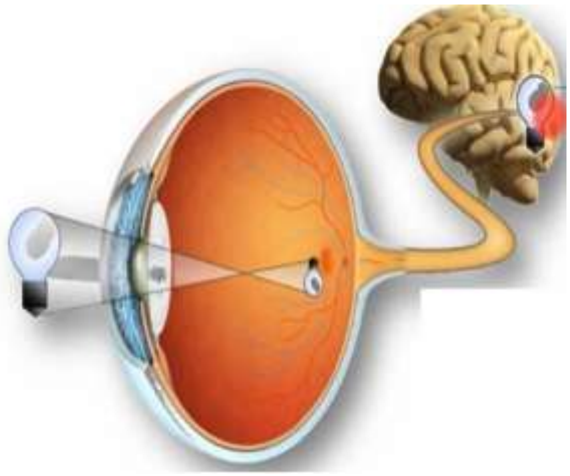
IR spectrometer's is used in analytical chemistry laboratories, are a benchmark for chemical identification based on each material's unique spectral 'fingerprint.'

1. Tunable IR wavelength from quantum cascade laser is tuned.
2. Depending upon the target's absorption band, there is a local heating due to absorption by potential chemicals.
3. IR cameras monitor such a change and suspect the target to be true, and send the location to the controller through GPS tracker to the smart phone as a message.
4. The already deployed trained CNN model helps the drone to maneuver based to its learning to the targets location automatically.



●WHY CONVOLUTIONAL NETWORK?

CNN's are powerful image processing, artificial neural network used in image processing that is specifically designed to process pixel data. Application of **DEEP LEARNING**. Uses multi layer perceptron that has been designed for reduced processing requirement, with input, output, and hidden layers. CNN are arranged more like that of the frontal lobe that is responsible for visual stimuli in human and other creatures.



CNN is a type of feed-forward artificial neural network system that is used in the process of connectivity pattern between its neurons and it is inspired by the organization of the animal visual cortex.

The visual cortex has small portion of cells that are sensitive to specific regions of the visual field. Some individual neuronal cells in the brain respond (or fires) only in the presence of edges of a certain orientation. For example, some neurons fires when exposed to the vertical edges and some neurons will fire when shown horizontal or diagonal edges.

● **TRACK IMO :**

Interfacing GPS module and drone software.The “true” output is taken as input to its program.

III. INFRARED AND

THERMAL RADIATION

Infrared radiation was originally discovered in 1800 by Sir Frederick William Herschel (1738-1822), who is also famous for discovering the planet Uranus as well as writing 24 symphonies (Rogalski (2012)). Infrared radiation is a part of the electromagnetic spectrum, and its name originates from the Latin word infra, which means below. That is, the infrared band lies below the visual red light band, since it has longer wavelength.

The infrared wavelength band is broadand is usually divided into different bands based on their different properties: near infrared (NIR, wavelengths 0.7– 1 μm), shortwave infrared (SWIR, 1–3 μm),midwave infrared (MWIR, 3–5 μm), and longwave infrared (LWIR, 8–12 μm). Other definitions exist as well. LWIR, and MWIR, is sometimes commonly mentioned to as thermal infrared (TIR). TIR cameras are sensitive to emitted radiation in everyday temperatures and should not be confused with NIR and SWIR cameras that, in contrast, mostly measure reflected radiation. These non-thermal cameras are dependent on illumination and behave in general in a similar way as visual cameras. When interacting with the matter then, electromagnetic radiations absorbed (α), transmitted (τ) and/or reflected (ρ).Thetotalradiationlawstatesthat$1=\alpha+\rho+\tau$ where α, τ, ρ [0, 1]. In addition, an object's thermal energy can be converted into electromagnetic energy, called thermal radiation. All objects with temperatures above absolute zero that will emit thermal radiation to a different extent depending on temperature and material that are suspected.

An object defined as a black body is an opaque and non-reflective object that absorbs all kinds of incident radiation that detect ($\alpha = 1$). Black bodies do not exist in nature, but are commonly used as an approximation. Examples of black body radiation curves can be seen in Fig. 2.1Note that the peak of the lies in the reflective part of the electromagnetic spectrum.

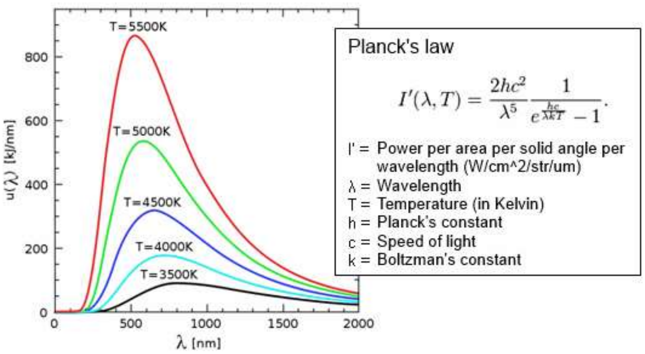


Fig 2.1

Emissivity (ρ)is the ratio of the actual emittance of an object to the emittance ofa black body at the same temperature. Further, Kirchhoff's law states that $\alpha = \rho$, i.e., $\rho = 1$ for a black body. Since emissivity is material dependant, it is animportantpropertywhenmeasuringtempera tureswithathermalcamera.Due to scattering by particles and absorption by gases, the atmosphere will attenuate radiation, making the measured apparent temperature decrease with increased distance. The level of attenuation depends on the radiation of the wavelength, Fig. 2.2. As can be seen in the figure, there are two main sections in which the atmosphere transmits a major part of the radiation. These are called as the atmospheric window and that value will befoundbetween3–5µm(represent mid-wave window)and 8–12 µm (represent long-wave window) (Rees (2001)).These windows correspond to the MWIR and LWIR bands mentioned above.

This below section will provides a brief descriptions of the topic.

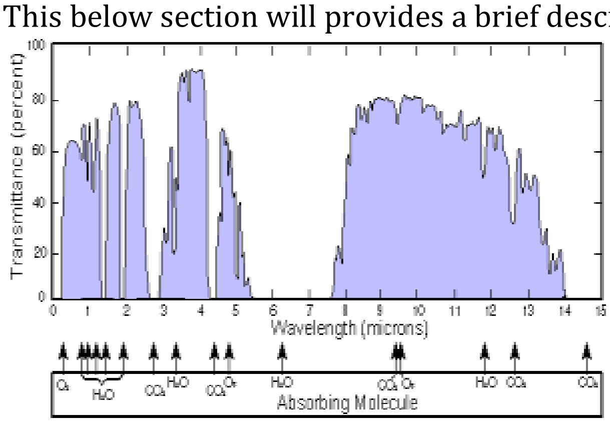


Fig 2.2

IV. DETECTION IN THERMALINFRARED

The main approach to detection in thermal infrared has historically been thresholding, so called hotspot detection. Thermal cameras were expensive, had low resolution

and interesting objects typically appeared as points (a few pixels, or even subpixels) in the image. In addition, typical objects of interest were those that are warmer than the background because they generate kinetic energy in order to move (e.g. airborne and ground vehicles). One example is airborne target detection where the object is only a few pixels wide (assuming low resolution) and the cold atmosphere serves as background. In recent years, new application areas have emerged and today, with increasing resolution, image quality, and a different set of applications, targets often span a larger pixel area, have varying temperature, and are deformable.

Thresholding combined with post- processing (e.g. merging and splitting of blobs) is an efficient detection technique in the case of high background/object contrast, a situation more or less common depending on application. Industrial applications can, for example, provide a controlled environment more suitable for Thresholding that others.

● Camouflage: Objects or parts of objects may have approximately the same temperature as the background. In the latter case, one object may thus give rise to several detections. For example, a humanoutside in the cold wearing an insulating coat. The coat will adopt the surrounding temperature, making it possible to extractonly the legs and head of the object with thresholding.

● Reflection: Different materials reflect thermal infrared to different extents, they have different reflectance. Wet asphalt is typically reflective as well as water puddles. Also glass has a low transmittance (and highreflectance) and will reflect most of the incoming thermal radiation. Thresholding as a detection method cannot differentiate real objects from reflected ones and may thus cause false detections.

● versatile background: There might be background or other objects in the scene thathaveasimilarappearance/intensityastheob jectweareinterestedin.Thresholding based on intensity will then give rise to false detections.

Humans try to maintain a constant body temperature which is favorable for detection algorithms. However, they also tend to wear insulating clothes making detection of humans in thermal infrared somewhat more challenging. The face of a human is typically not covered by clothes unlike the rest of the body and might therefore be easier to extract from an image. Zin et al.

(2007) and Wonget al. (2010) exploit this fact by thresholding and incorporating shape information for human detection.

Some detection methods exploit the advantages of the visual and thermal modality respectively by combining information extracted from visual and thermal imagery of the same scene (Hwang et al. (2015); Apatean et al. (2010); Kroto- sky and Trivedi (2008)).
It is also possible to affect the temperature of the object in order to find anomalies by observing how the heat is transferred through the material. Within the field of Non-Destructive Testing (NDT), an excitation source such as a flash lamp can beused to heat the material. The process of cooling down is recorded with a high-end thermal infrared sensor that will help us to detect the problem and can be solved in an efficient manner. Anomalies in the material will result in anomalous heat transfer which can be detected by observing the surface. Runnemalmet al. (2014) use the described technique to detect defective spot welds.

V. TRACKING IN THERMALINFRARED

Regarding object tracking in thermal infrared imagery, there are two common beliefs. The first is that it is all about detecting and tracking the things that are warm and act against cold back- grounds, so it is called as hot spot tracking. This type of supposition that will be valid only for certain type of applications like tracking of aircrafts against a cold sky, but for most of the other applications the situation is more complex. For example, in a surveillance application, the object can be warmer than the background initially, but as the day progresses and the sun rises and heats the surroundings, it might end up colder than thebackground.

The second common belief is that tracking in thermal infrared is identical to tracking in grayscale visual imagery. Accordingly, a good tracker for visual imagery should also be a good tracker for thermal infrared visualizations. The hotspot tracking is applicable only for some specific application and benchmarks were performed where trackers gave different results on RGB and thermal infrared sequences respectively to detect and solve that particular problem.

Differences between tracking thermal infrared radiations and visual imagery
The differences between thermal and visual imagery. The described characteristics of thermal infrared imagery indicate that tracking in thermal imagery is not identical to tracking in grayscale visual imagery. First, a tracker that depends heavily on (high resolution) spatial structure is presumably suboptimal for thermal infrared imagery since such imagery has a different noise characteristic, e.g., lower resolution and more blooming.

Secondly, the absence of shadows that will help a tracker to design and to handle shadows suboptimal for thermal infrared imagery radiations. Third, the visual coloring patterns are discernible in the thermal infrared spectrum that can only correspond to variations in material or temperature. Moreover, re-identification and resolving the final occlusions might need to be done differently to solve the problems. For example, two persons with differently patterned or colored clothes might look similar in thermal infrared imagery. Fourth, trackers that exploit the absolute levels (for example, distribution field trackers) should have an advantage in thermal infrared imagery due to the fact that the emitted radiation change and will slower than the reflected radiation in most of the applications. Fifth, trackers that will be able to exploit 16-bit of data from radiometric cameras that will have an great advantage since they have a dynamic range that is large enough to accommodate to relevant temperature intervals without adapting the dynamic range to each of the frame.

Finally, perhaps the most obvious one, there is no color in thermal infrared imagery and trackers relying on color features are, therefore, not suitable for thermal infrared imagery. Video-rate multispectral thermal cameras exist but they are rare and out of scope of this thesis. If all these specificsmentioned above are considered, it should be possible to design a tracker superior on thermal infrared data.

VI. DRONE SCIENCE

● Vertical Motion:

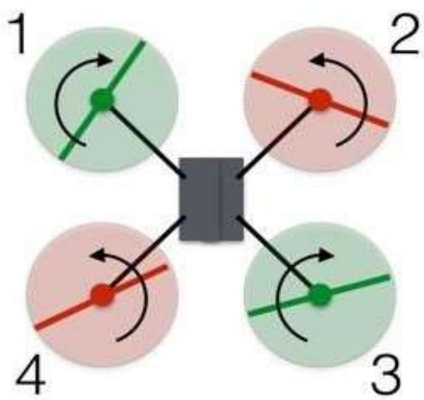
Drones use rotors for propulsive impulsive power and control. Drone contains rotors with spinning blades push air down where rotor pushes down on the air, the air pushes up on the rotor. This is the basic idea behind elevator, which comes down to controlling the downward and upward force. The faster the rotors spin, the greater and higher the lift moves, and vice-versa.

A drone can do three main things in thevertical plane, they are: hover, climb, or descend. To hover, the net thrust of the four rotors it will push the drone up and that mustbe equal to the gravitational force which willpulls it down and that will just increase the speed of the four rotors so that there is a non-zero upward force that is simply greater than the weight (mass). Then we should decrease the thrust a little bit–but now there are three forces acting on the drone: weight, thrust, and air drag. So, you will still need for the thrusters to be greater than for just a hover. When coming to descending it requires doing the exact opposite where we should simply decrease the rotors thrust (speed) so the net force is downward.

● Turning (Rotating):

In the below shown configuration, the red rotors will rotate in counter clockwise direction and the green rotors will rotate in clockwise direction. Here the two sets ofrotors will start rotating in oppositedirections, so the total angular momentum iszero. Angular momentum is a simply like linear momentum, by which we can calculate it by multiplying the angular velocity by the moment of inertia. Moment of inertia is nothing but it is similar to the mass, excluding it deals with rotation. Angular momentum just depends only on how fast the rotors spin.

If there is no torque on the system (the system here being the drone), then the total angular momentum must remain constant (zero in this case).Now let’s assume the red counterclockwise rotors have a positiveangular momentum and the green clockwise rotors have a negative angular momentum. By assigning each rotor a value of +2, +2, - 2, -2, this adds up to zero.



Now if we want to rotate the drone to the right. Suppose I decrease the angular velocity of rotor 1 such that now it has an angular momentum of -1 instead of -2. If nothing else happened in that case, the total angular momentum of the drone would now be +1. But that can't happen. So the drone rotates clockwise and the body of the drone has an angular momentum of -1.

By decreasing the spin of rotor 1 that will cause the drone to rotate, but it also decreasethe thrust from rotor 1. Now the net upward force will not equal the gravitational force, and the drone descends.

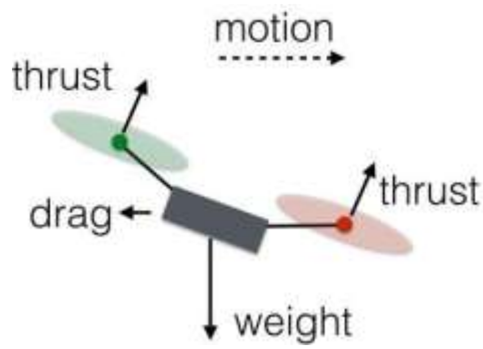
To rotate the drone without creating any problems, increase the spin for rotors 2 and 4, and decrease the spin of rotor 1 and 3. Still the angular momentum of the rotors doesn't add up to zero, so the drone body must rotate. But indeed the total force remains equal to the gravitational force and the drone will continues to hover. Since the lower thrust of the rotors are diagonally opposite from each other, the drone can still be balanced.

- **Forwards and Sideways:**

The difference between moving the drone forward or backward is nothing,because it is symmetrical. It is same for side-to-side motion. Above all a quad copter

drone is similar to a car where every side is the front. This means that explaining how to move forward is also the same when it explains how to move back or to either side.

In order to fly forward, we need a forward the component of thrust from the rotors. Side view (with forces) of a drone moves at a constant speed. For that we should increase the rotation rate of rotors 4 and 3 (the rear ones) and decrease the rate of rotors 1 and 2.The net total thrust force will remain equal to the weight, so that the drone will remain at the same vertical level.



Also, when one of the rear rotors is spinning counterclockwise and the other clockwise,the increased rotation of those rotors will still produce a zero angular momentum. It is same for the front rotors, and so the drone does not rotate. Whereas, the greater force in the back of the drone means it will tilt forward. Now a slight increase in the thrust of the drones all rotors will produce a net thrust force that will have a component to balance the weight along with a forward motion component.

- **Using a Computer:**

As we know that every movement is accomplished by changing the spin rate of one or more rotors of the drone. For doing this we just require a controller that can increase or decrease the voltage to each motor. It's not that much difficult to set up. Just imagine that we have a drone with 4 controllers and we need one controller for each motor power level. It would be difficult to manually adjust each motor power to achieve the desired motion. So, if we have some type of computer control system, we can simply operate the joysticks and let a computer handle all of that. Accelerometer and gyroscope in the drone can further increase the simplicity and stability of flight by making a minute adjustment in the powerto each rotor. By adding a GPS system and we can pretty much get rid of the human entirely. So we can see the flying of a drone is quite easy if we let the computer do all thework.

VII. PLASTICS EXPLOSIVES

Plastic explosive is a soft and hand- moldable solid form of explosive materials. Within the field of explosives engineeringthe plastic explosives are also known as putty explosives. These explosives are especially suited only for the explosive demolition. Some commonly used plastic explosives include Semtex and C-4. The first plastic explosive discovered was gelignite in the year 1875 and that was invented by Alfred Nobel.

Plastic explosives are especially suited for explosive demolition of hurdle and rampart by engineers, combat

engineers and criminals as they can be easily established into the best shapes for cutting structural members and to have a high enough velocity of explosion of discharge and density for metal cutting work. An early use of plastic explosives was developed in the warhead of the Petard demolition mortar of the British Armored Vehicle Royal Engineers (AVRE).It said mortar was used to destroy concrete explosions that are encountered during the Operation Overlord (D-Day). The initial use of Nobel 808 supplied by the SOE was for Sabotage of German installations and railways in Occupied in Europe.

They are not generally used for ordinary blasting of bomb as they tend to be significantly more expensive than other kinds of materials that perform just as well in this application. A common commercial use of plastic explosives is for shock hardening substances with high amount ofmanganese percentage steel, a material typically used for railway components and earth digging implementations.

Reactive armor in tanks that will use the plastic explosives that are sandwiched in-between two plates of steel. Incoming high explosive anti-tank rounds will penetrate theouter steel plate, and then it began to explode the plastic explosives. This will absorb the energy from the incoming tank that is rounded and shields the tank.

- COMPOSITION C:

During the period of World War II British used a plastic explosive as a demolition charge. The specific type of explosive is Composition C which contain11.7% non- oily, 88.3% RDX and non-explosive plasticizer.

The plastic materials were between 0 and
40 degrees C, but it was brittle at colder temperatures and viscous at the higher temperatures. Composition C was thrown byComposition C2, which is used as a mixture of 20% plasticizer and 80% RDX.

Composition C2 had a wide amount of temperature range at which it remains plastic, from −30 to 52 degrees C. Composition C2 was replaced by Composition C3, which was a mixture of77% RDX and 23% explosive plasticizer.C3 was effective but proved to be too brittle in cold weather and was replaced with C4. There are three classes of C4, with varying amounts of RDX and polyisobutylene.

- **LIST OF PLASTICS EXPLOSIVES:**

a) Austria: KNAUERIT SPEZIAL
b) Czech Republic: Semtex-1H (orange- colored), Semtex 10 (also called Pl Np 10; black-colored),Semtex 1A (red- colored), Pl Hx 30 (gray-colored)
c) Finland: PENO
d) France: Hexomax (PE7), PLASTRITE (FORMEX P1, Pla Np 87)
e) Germany: P8301,Seismoplast1(Sprengmasse formbar)SprengkörperDM12,
f) Netherlands: Knaverit S1 (light orange-colored)
g) Greece: C3, C4
h) Israel: Semtex
i) Italy: T-4 Plastico
j) Norway: NM91 (HMX), C4, DPX10(PE8)
k) Poland: PMW, NITROLIT

l) Russia: PVV-5A Plastic Explosive
Slovakia: CHEMEX (C4), TVAREX

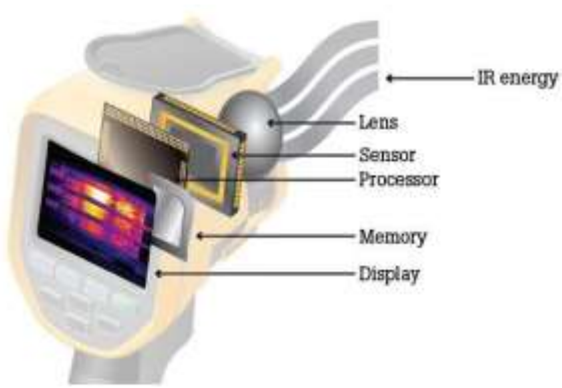
4A, Pl Hx 30

m) Sweden: Sprängdeg m/46, NSP711(PETN-based), NSH711 (cyclonite-based)
n) Switzerland: PLASTEX produced by SSE
o) USA: C-4 (Composition C-4) (purewhite)
p) United Kingdom: PE4, PE7, PE8 (off-white-colored), DEMEX (sheet explosive)
q) Yugoslavia/Serbia: PP–01 (C4)

VIII. WORKING OF INFRAREDCAMERAS

All objects which discharge infrared energy, known as a heat signature. An infrared camera (also known as a thermal camera) that detects and measures the infrared energy of any kind of objects. This camera will help us to convert the infrared data into an electronic image that will show the apparent surface temperature of the object that are detected or suspected.

A thermal camera that will contain an optical system that focus on infrared (thermal) energy onto a special detector chip (sensor array) which contains thousands of detector sensor pixels arranged in a grid. Each pixel in the sensor array reacts to the thermal (infrared) energy focused on it and produces an electronic signal. The camera's processor will takes the signal from each pixel that are gathered and applies a mathematical calculation to it to create a color map of the obvious temperature of the object. For each temperature value is assigned a different color. An input of the resulting matrix of thecolors is sent to memory and to the camera's display as a temperature picture (thermal image) of any particular object.



Many thermal cameras which also include a visible light camera that helps us to automatically capture a standard digital image with each pull of the trigger. By merging these images it will make us easier to correspond the problem areas in our thermal image with the actual equipment or the spot that inspecting. Infrared-Fusion technology will help us to combine a visible light image with an infrared thermal image with pixel-to-pixel alignment. We can change or alter the intensity of the visible light image and the infrared image to see the problem more accurately in the infrared image or to locate it within the visible light image.

Beyond the basic functional thermal imaging capabilities, you can find infrared cameras with a larger range of additional features like allow voice annotations, enhance resolution, automate functions, record and stream video of the images, and support analysis and reporting.

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