Report Title: 'good distance based detection of explosive materials'

Motivation(s): Through the subject course, I learned that:

Synchrotron Radiations may have tremendous useful applications in few unexplored/underutilized disciplines like (i) Homeland Securities Managements (ii) Quality Assurance of Heavy Industry/Duty Equipments and (iii) Constructive Genetic Engineering Applications like various agro products qualitative as well as quantitative enhancements etc.

I decided to utilize leaned knowledge of subject course in designing a may be high demand homeland security application, '*good distance based detection of explosive materials*'.

The good reason to this selection is: '***present fast emerging new securities scenarios and crying needs to appropriately as well as adequately encounter them***'.

Explosive Materials: An explosive material is a material that either is chemically or otherwise energetically unstable or produces a sudden expansion of the material usually accompanied by the production of heat and large changes in pressure (and typically also a flash and/or loud noise) upon initiation.

An explosive charge is a measured quantity of explosive material. An explosive may consist of either a chemically pure compound, such as nitro-glycerine, or a mixture of an oxidizer and a fuel, such as black powder.

There is a huge list of explosive materials, Dynamite, TNT, RDX, PETN, HMX are few common names having quite huge destructive potential(s).

How can we detect an explosive material from a good distance?

Our conventional detection systems:

Dogs, honey bees, spectroscopy, comparing reflected ultraviolet, infrared and visible light measurements on multiple areas of the suspect material.

The present fast emerging security scenarios demand detection of explosive materials from a good distance.

Therefore up gradation or replacement of aforesaid conventional detection systems should be done.

To design a good distance based detection system, we need to have (i) a comparatively long range radioactive source of energy but necessarily un-harmful to the propagating medias'. (ii) An efficient and high reliable detection as well as analysis system(s) are also required to be attached with this source.

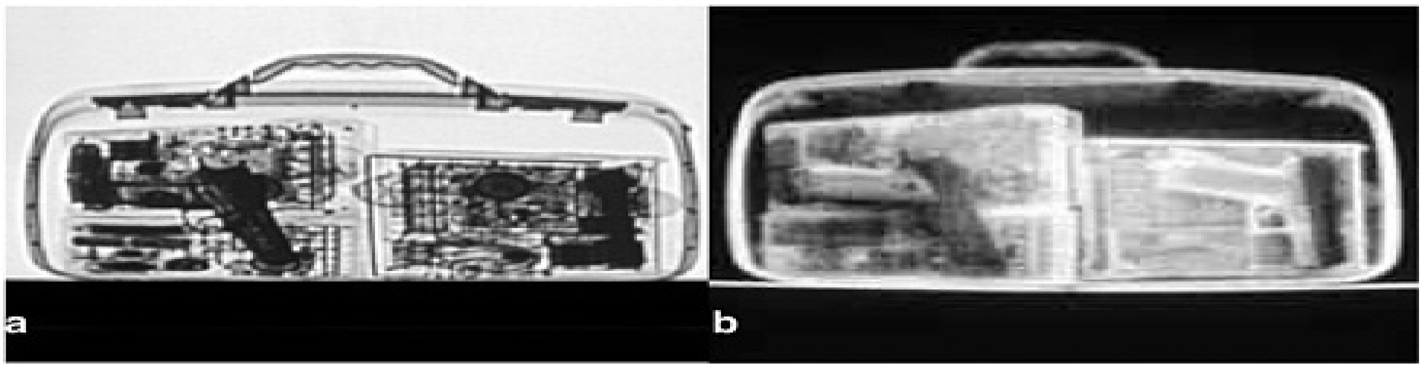
X-rays as strong candidate to detect explosives from good distances:

Most bombs (explosive materials) have distinguishing spatial features and uniquely shaped metal components such as wires, detonators, and batteries. Explosive dielectric constants allow at least a limited discrimination from the background for X-ray and microwave imaging techniques. The reflection, absorption, and scattering for various explosives in a set of spectral bands which can be categorized, and this information can be used as a data base for image analysis.

Since X-ray radiation is ionizing, there are health concerns when people are exposed to it. However, for imaging out to standoff distances of 10 to 20 meters, these health issues may not be prohibitive.

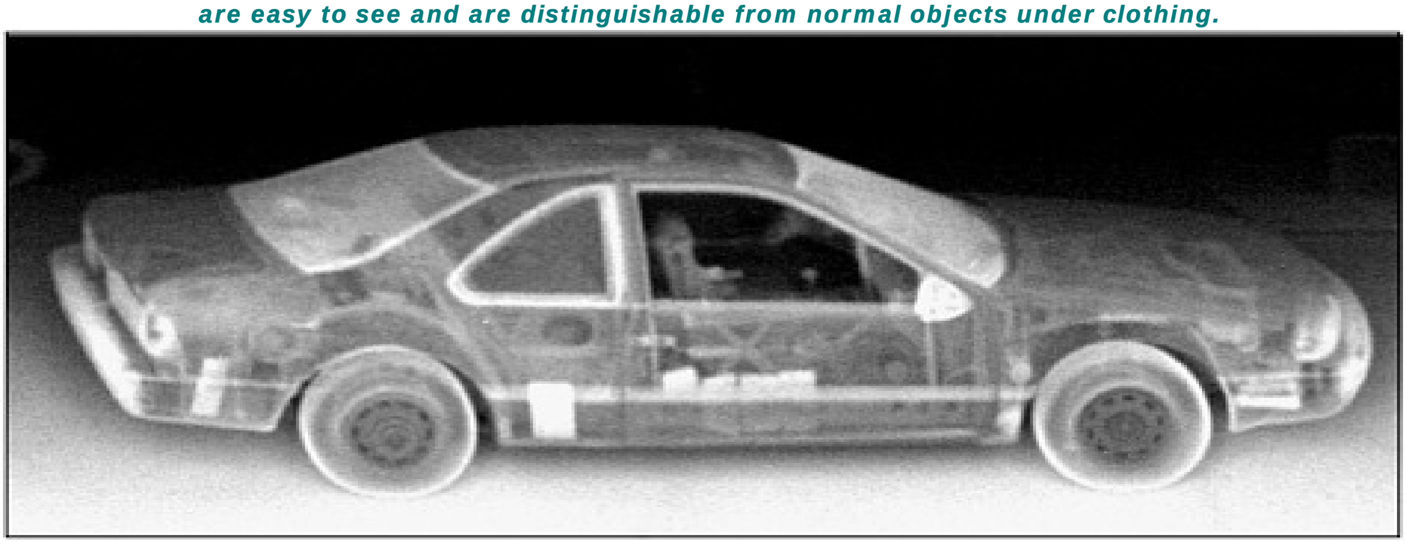
Transmission X-ray imaging requires a detector on the opposite side of the target from the transmitter. The detector could be a low-cost plastic sheet monitored by an inexpensive camera with a wireless link to a data analysis base. Inexpensive detectors and cameras could be concealed and replaced if they are damaged. Transmission images give good resolution and detect shapes of objects shadowed as a result of their high X-ray absorption.

However, X-ray imaging uses backscattering where both detector and transmitter are collocated. The backscattered image is bright for organic materials since the incident and backscattered X-rays penetrate deep into the organic materials, where atoms contain fewer electrons than the atoms in materials (e.g., metals) made of heavier elements. As in the case of transmission imaging, the detectors for backscattering could be located closer to the target than the transmitter to enhance image resolution and decrease losses caused by absorption in air and also the angular spread of the beam.



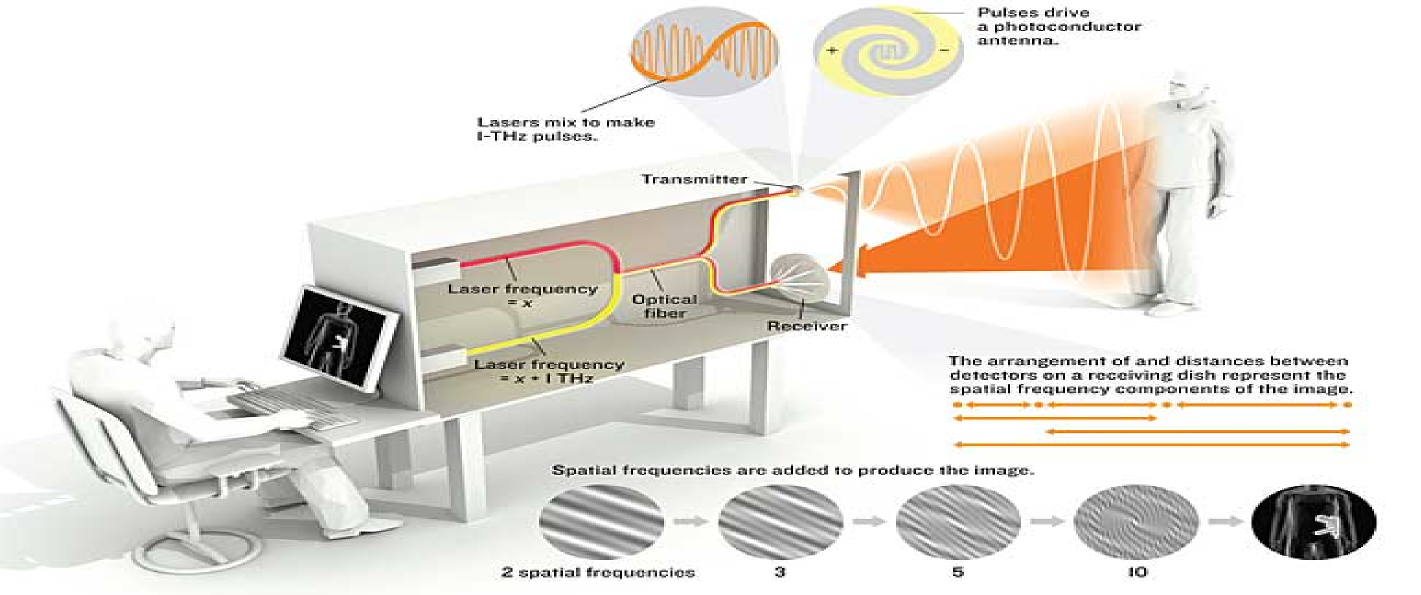
(a) Transmission and (b) backscatter X-ray images of a suitcase containing two guns, one plastic and one metal. The transmission image (a) shows a radio on the right in which a plastic Glock 17 automatic pistol is concealed. A metal gun is visible in image (a). The backscatter image of the same suitcase in (b) clearly shows the plastic gun on the right.

Standoff X-ray detection showing hidden explosives and other items on personnel. Images were taken from a van moving at 0.3 to 6 miles per hour using X-ray backscattering in "drive-by" mode. The mock suicide vest contained simulated C4 explosives and pipe bombs. Both the explosives and the pipe bombs are easy to see and are distinguishable from normal objects under clothing.



X-ray image of a car containing C4 explosive packages (just in front of the front wheel, to the rear of the door, in the roof just above the door, and in the back fender), drugs (in the door), and a 150 pound ANFO (ammonium nitrate-fuel oil) bomb with a grenade detonator (in the trunk).

Proposed setup to detect explosive materials from a good distance:



The design parameters of this proposed design will be given in separate paper

High photon flux X-ray sources, pulsed X-ray sources, smaller focal spots for scanned beams, and focused X-ray beams can contribute to the successful development of standoff X-ray imagers. Lower-energy X-rays (<100 keV) may have potential for better discrimination between organic and inorganic materials. However, the lower-energy region has the disadvantage of higher absorption in air as well as in the explosive apparatus/materials.
Computer image analysis to get better image interpretation will also solve the privacy issues that arise with images of people in which private body parts appear. People may be less likely to object to image analysis if no one will actually see the images and if the images can be "deleted" immediately after completing analysis.

Conclusions and Recommendations:

A combination of both transmission and backscatter aids in detection since the transmission images have better resolution and the backscatter images have better discrimination between organic and non-organic materials.
Dual-energy X-ray sources will further enhances the discrimination between organic and non-organic compounds, specifically between explosives and background objects.
X-ray imaging has good potential for standoff detection for distances up to approximately 15 m (can be optimized/extended). Its advantages are excellent image resolution along with limited discrimination between explosives and background items.
The disadvantages of X-ray imaging may be the perceived health concerns that arise with ionizing radiation as well as the cultural and legal issues that arise when imaging people through their clothing.
Optimization of 'good standoff distance' for X-rays will be a real challenge.
The cost and size of X-ray detection systems will also be a good concern.

References:

Ref[1] **http://www.google.com**
Ref[2] **http://science.howstuffworks.com**
Ref[3] **http://books.nap.edu/openbook**