June 17, 2019

TAMPER-PROOF WEAPONS AND COMPONENTS IDENTIFICATIONS AND DIAGNOSIS WITH ACTIVE RADIATION

David Maluf

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David A. Maluf, Ph.D.
Mountain View, California, USA

ABSTRACT

Convergence and increased complexity has made tracking components and inventory, especially high value or security risks an increasingly large scale, distributed challenge for: federal, state, and local government agencies, industries, municipal operations centers (airports, docks, etc.) and other large public concerns. Lifecycle management includes component stress analysis and overall health. The methods hereby address the detection, identification and integrity of movable components in a tamper-proof manner. The selection of radioactive materials, radioactive lifecycle, their density and material insertion, and uniformity in insertion during manufacturing determine the type process in identification. A receiver sensor may be built upon geiger counter methods which are widely available technologies. The receivers will display heatmaps of the radiation distribution or trigger configured notifications when the radioactive waves are within proximity sensors with sufficient range and fidelity to make detection and tracking economical.

BACKGROUND

NASA has launched in 2002 the Engineering for Complex Program (ECS) as a subsequent result from the investigation of Columbia Shuttle Accident. Investigation for defect detection became a top priority for the agency. Many novel ideas were investigated and developed during the Engineering for Complex Systems program (ECS). The program conducted research and development for all engineering lifecycle phases with enhancements in risk management and health diagnostics assessments. During that process, requirements were gathered that helped formulate the current “Components Identifications and Diagnostics With Active Radiation” work. The ECS R&D efforts had broad applicability including aeronautics, military and commercial aviation manufacturing. In particular vehicle manufacturers are challenged to track millions of components to help the prevention of parts or components of being lost, stolen, or counterfeited. Although tagging technologies such as RFID have been developed that technology still has key weaknesses in robustness and integrity control.

The goal of the ECS program was to deliver strategic state-of-the-art advances in risk analysis and mitigation for all of NASA missions including real-time/run-time beyond ground operations health management and diagnostics. The following section below delivers on some of the originating concepts.

DESCRIPTION OF THE PROBLEM AND OBJECTIVE

Tracking globally distributed components is a significant challenge for many organizations and government agencies including commercial industry, federal, state government, port authorities, and the general public. Full lifecycle tracking of high value and/or risk items is important to maintain safety, security, and to reduce the potential for loss, integrity degradation and to help prevent/identify counterfeits. Shortfalls in this capability for complex and convergent components and systems have global economic impacts. An example problem is when a stolen aircraft is sold on the black market for parts and there is no way to track the parts beyond basic visual inspection. An efficient, low cost, reliable method is required to deal with these types of problems.

The same issue is prevalent today with firearms and public safety. Quick, low cost, reliable methods are required to identify the presence of firearms in public locations to enable the authorities to detect their presence and validate their authorization to be present. The objective to solve for the identification and tracking of a component, tamper-proof, and especially for transit mode, when guns are getting in proximity of prohibited zones such as schools, churches, or ports. Lastly, material failure from stress such as engines, turbines, and space vehicle heat shields can be analyzed in real time for stress or fracture with differential analysis and comparison of the radiating waves from baselines.

The state of the art proximity sensing use cases in the current industry rely on addon tagging technology; with the proximity sensors having to be near the objects. Tagging technology is NOT tamper-proof.

TECHNOLOGY DESCRIPTION

The methods hereby address the detection, identification, and diagnostics of movable components in a tamper-proof manner. Primarily intended for metal-based (e.g. steel or other metals) components, the methods assert that components are either tainted, mixed while in the mold, or specially painted with radioactive materials. The selection of radioactive materials, density wave types, and uniformity in manufacturing determine the type process in the identification and analysis. Radioactivity emits different types of radiation waves, and some of these radiation types may penetrate the protective gear, walls or other obstacles. A receiver sensor is built on geiger counter methods, a widely available technology. The receiver will generate heat a map and/or trigger configured notifications when the radioactive waves are within proximity sensors.

There is a natural and difficult boundary to tamper with the removal of radioactive materials without total destruction. The radioactive active materials should be infused at the appropriate concentration levels for public safety and hazard minimums to meet users/public expected exposure requirements. There are many types of radioactive materials that meet public safety requirements. Many of these radioactive materials also have long decay lives that exceed, by many times, the expected viable lifetimes of the components (i.e in centuries) in question.

A first example is to consider when a lightweight gun's barrel is mixed with radioactive materials and a geiger counter receiver sensor device is carried by a law enforcement agent. When an individual carrying the radioactive gun enters the region of proximity of the geiger counter, the sensor picks up the radiation waves and issues a notification signal consisting of strength levels. Given multiple sensors available on the premises which can detect the radiation, simple methods of triangulation may derive the location of the gun. This applies also to gun components such as the gun's magazine and even bullets.

Another example is when military equipment is manufactured and specific components are tainted or mixed with radioactive materials. These materials become readily detected by sensors. Government supplied weapons often allocated to a wide range of third parties and mercenaries for sanction use. However, after the sanctioned use is over, weapons are rarely recovered and instead are sold on the black market,often ending up being misused in numerous ways.

The same sensors (i.e. Geiger counter) could detect radiation from a distance. Given an approximated distance measurement, the measure of the radiation spread and intensity value can be derived to compute a quantification measure in terms of size, volume, or mass of the target components. For example, stolen weapons that have fallen in the hands of assailants can be tracked and assessed. Other approaches in military use cases are to deploy notifications systems or other remedies which are put in place to respond to the detection of these components within a given proximity.

These component types could vary across domains. In industrial use cases, they may be aircraft components or ground systems (tanks, artillery, vehicles, support, etc.), spacecraft or naval components. The military use cases will vary from tracking stolen components in manufacturing, to deterring counterfeits, to the battlefield as enhanced situational awareness. For the battlefield example, a fly-by drone can pick up the radiation from stolen components.

Materials Fracture and Stress Analysis

The example of material stress analysis involves the process of mixing or tainting radioactive materials with the components that likely will undergo stress in their usage such as heat shields in re-entry vehicles, space components etc.. The process in the manufacturing should guarantee the proper uniform distribution of radioactive materials in the components. The manufacturing signatures of radiation profiles are measured and kept as a quality reference baseline. When stress, fractures, microfractures, or other deformities occur, the radiation signatures will vary from the baseline reference signature from the date of production. This process is also valuable for automotive manufacturing such as engine heads or gears and applicable, as well, in the aircraft industry. Engines over time endure microfractures and eventually fail (e.g. blown heads). Radioactive tainting can be used as a method of diagnostics and analysis in real time or in maintenance. It will enable low-cost analysis of the area and cross section of the components which are not accessible to standard methods for analysis.

Example for lightweight barreled guns in Public Safety

The example of the proposed methods to address lightweight guns is as follows. A gun shall be tainted or mixed with radioactive materials to trigger proximity sensors. The radioactive active materials can be infused at low concentrations to meet public safety and hazard regulations for long human exposures yet high enough to trigger the proximity sensors. The sections below describe the specific recommendations to meet the implementation of lightweight firearm identifications.

When firearms are tainted or mixed with radioactive materials, they are readily detected by sensors. These sensors are positioned in the ingress and egress areas of schools or other public areas where it is prohibited to have a firearm or firearm control is desired. These sensors could detect radiation from the appropriate distances. Heatmaps, alarms, and notifications systems are put in place in response to the detection of firearms in the sensor's proximity.

Hardware Recommendations

In the creation of the hardware, the radioactive substance must meet certain requirements in order to be compatible. When choosing the part of the hardware to incorporate the radioactive substance into, it is important to consider the following factors:

- Which part is crucial and cannot be removed. If the part cannot be removed, the part cannot be exchanged for a non-radioactive part.
- The part becoming radioactive should also be as consistent as possible in/on the material used so that manufacturing is easier.
- The part should also be substantial enough that adding the radioactive substance won't dramatically change the integrity of the material.
    - Considering these factors, the barrel of the hardware is recommended. The barrel is consistent, compared to other parts of the hardware, in that it is commonly made of chromium molybdenum alloy steel 4140, 4150 steel, 4340 steel, or 416 stainless steel. The barrel is the most crucial part of the hardware and requires a manufacturer to change.
    - Variations to steel include other materials such as synthetic or semi-synthetic organic materials (e.g. plastics).

Radioactive Material Requirements

When choosing a radioactive substance, the following factors need to be considered:

- The half-life must be long enough that the hardware will remain radioactive for an amount of time that warrants the cost of adding the radioactive material.
- The radioactive material must not be toxic to humans and must emit a radioactive dose that is less than 100 millirems a year.
- The material must have enough activity so that it can be reliably detected at reasonable distances.

- The material recommended must emit gamma radiation because alpha and beta radiation can be shielded with a significantly smaller amount of material.
- A relatively inexpensive metal is the preferred material as the radioactive source target.
- It is also preferable that the material not be too common in everyday life so as to limit the amount of false positive readings when scanning an area.

Material Recommendation

The radioactive material that meets all of the above requirements is Molybdenum 93. Molybdenum 93 has a half-life of 4,000 years and will, therefore, be radioactive for a substantial amount of time. The substance has a specific activity of approximately 0.934079 curies/gram with a decay energy of 404.78 keV, which is enough activity in order to be detected at a reasonable distance. Molybdenum 93 emits gamma radiation and is made by neutron activation of the stable isotope Molybdenum 92. Molybdenum is inexpensive at $30/lb but the machinery required for neutron activation is very expensive. However, this machinery is required to make almost all radioactive substances because almost all are synthetically made. Molybdenum 93 is not commonly used in industry or medicine and will, therefore, have very little background radiation. Molybdenum has other benefits such that it is already being used in the barrels of the hardware and that it is mined in the United States. Molybdenum is also used in alloys to add strength and corrosion resistance.

FEATURES

The proposed features are as follows:

- The ability to perform fracture and stress analysis of materials and components.
- The ability to perform fracture and stress analysis in real-time, run-time remotely. Ideal for space operation, spacecraft health analysis, etc.
- The ability to detect firearms for public safety in designated areas using radioactive materials.
- The ability to efficiently and reliably detect and identify industrial and government components in use or in storage for the purpose of tracking.
- The ability to identify components for the purpose of identifying theft or counterfeits.
- The ability to identify components in military operations.
- Lifecycle management of components and signatures of original parts and non-original parts in various use cases including military and ground operations.
- The type of ideal metal of steel to use.
- The type of radioactive material to use that meets public safety.
- Geiger counters designed for individual mobile devices for personal gun detection and protection.
- Triangulations methods to detect radiation source (i.e. components) using alpha, beta and gamma rays as the source.
- Networked geiger apparatus mounted at optimal locations to notify detections.
- The ability to produce telemetry from sensors parametrically in dimensions of time of detection, type of radiation and strength of ration.

SPECULATION ON PUBLIC AND COMMERCIAL IMPACT

Given the increase of large scale mass violence episodes and globalization of firearms, it is critical that organizations and individuals in society, for public safety and security, maintain their right to defend themselves in sensing threats beforehand. The technology enables national governments or local security agencies to economically mandate and implement such capabilities in tamper-proof detections of high impact devices. The commoditization of these methods is made accessible to the public to their development under US government innovations.