RAPIER TECHNOLOGY GROUP

ALQIMI

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SECURING DIVERSE SUPPLY CHAINS AGAINST COUNTERFEITING

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THE CONCEPT

Seamless, discreet and integrated tracking and reporting of products within the manufacturing and sales supply chain.

Track and Trace

Robust

Authentication

Covert

Keying

Rapier Technology Group has developed an **integrated supply chain monitoring and authentication platform** that integrates unclonable identifiers, assembly line scanners, smartphone scanners, and a backend Cloud database. Using our proprietary machine learning algorithms, we are able to **reliably and automatically create fingerprints** for **pre-existing identifiers** comprising **intrinsic, unclonable signatures.**

Our process is compliant with common manufacturing methods, such as **laser etching, inkjet printing, thermal printing, and more.** Using an assembly line scanner, the tagged and indexed item can be verified as readable and be filed into a backend database to be used in lifecycle monitoring. Additionally, using a common smartphone camera, the identifier can not only be read as a normal barcode, but the part authenticity information can be read and verified.

At the point of manufacture for the product, the identifier is printed and indexed into the database with manufacturer information and date and time of manufacture. Next, the supplier of new or aftermarket parts/products can verify the authenticity of the sold parts and **reject counterfeits before they reach their clients.** Finally, before any product is put into end-use, the user can not only verify the authenticity of the part but also trace its path through the supply chain if there are questions.

This integrated system completes a full chain of custody and allows for a fully auditable lifecycle for each individual part.

By incorporating cutting-edge features and functionalities, Rapier Technology Group securely and instantaneously relays crucial information to manufacturers, suppliers, and end users.

PRELIMINARY RESULTS

Extreme accuracy using high- and low-quality image sensors, with extensive testing on more varied manufacturing processes in the immediate future.

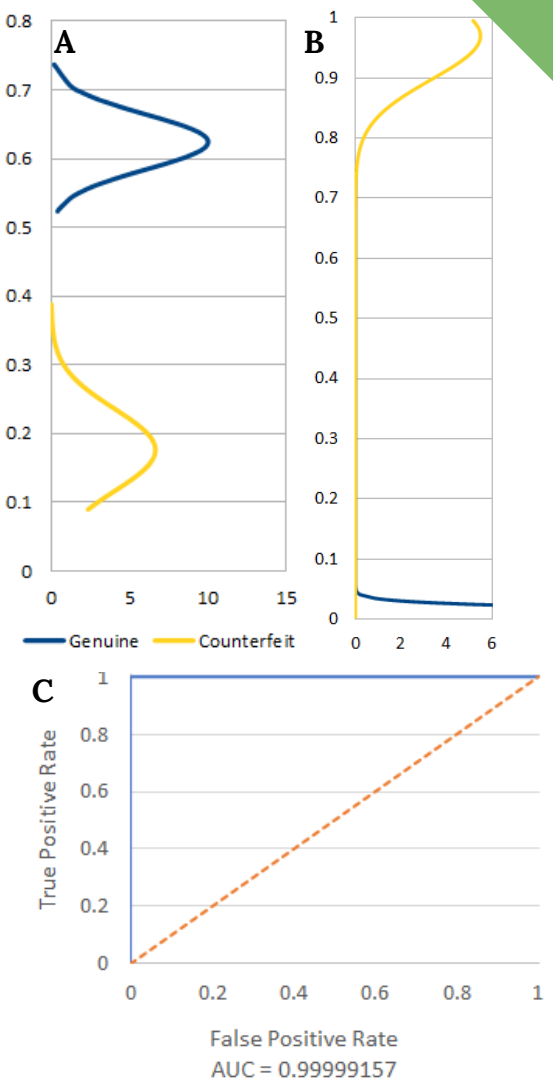
By analyzing identifier edges and how they overlap, the actual uniqueness of the printed codes can be characterized and used for counterfeit detection.

A novel and proprietary similarity coefficient is used to analyze the similarity between the two characters through the division of a union mask and a logical AND mask. After the processing of these datasets to retrieve the necessary coefficients, two comparisons were performed using SPSS (IBM Corp, IBM SPSS Statistics for Windows, Version 24.0, NY: IBM Corp.).

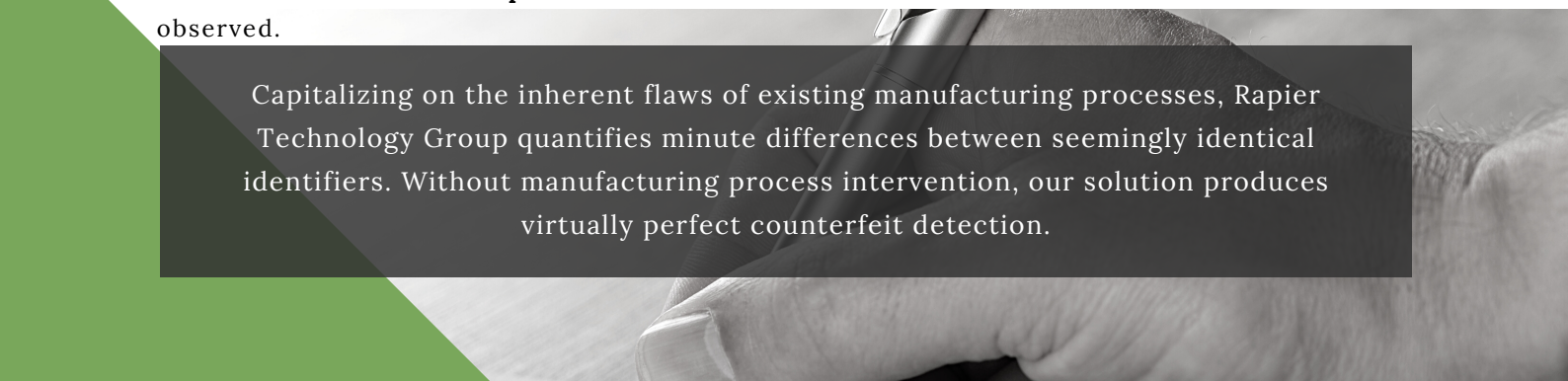
The first comparison tested the consistency of edge detection on two images of the same printed code, and the second comparison assessed the similarity of other, "identical" codes printed in the same dataset. A paired-samples t-test was conducted to assess character similarity across the two image sets.

The analysis of a microscope-based dataset found significant ($p < 0.001$) mean differences in edge detection correlation between **"genuine" (0.6243 ± 0.03983)** and **"counterfeit" (0.1763 ± 0.06000)** samples. There was **no overlap between datasets**, and both false positive and false negative rates were 0.00% across all comparisons.

The analysis of a smartphone-based dataset found significant ($p < 0.001$) mean differences in edge detection correlation between **"genuine" (0.9700026 ± 0.07272702)** and **"counterfeit" (0.00060388 ± 0.01273719)** samples. With an optimal Sørensen-Dice Coefficient cutoff point of 0.42531342, a **true positive rate of 99.435%** and **false positive rate of 0.025%** are observed.



(A) Distribution plots for a dataset collected with a desktop microscope (10MP); (B) Distribution plots for a dataset collected using a smartphone application; (C) ROC curve and AUC reporting for smartphone algorithm true positive/false positive rates.



Capitalizing on the inherent flaws of existing manufacturing processes, Rapier Technology Group quantifies minute differences between seemingly identical identifiers. Without manufacturing process intervention, our solution produces virtually perfect counterfeit detection.

HOW WE DO IT

Flawless results to date, with extensive testing on more varied manufacturing processes planned for the immediate future.

Our proprietary machine learning algorithm relies on the fact that all common manufacturing methods introduce imperfections, and these imperfections can be photographed and compared to determine if two identifiers (i.e. barcodes) are identical or not.

01 Find Identifier Landmarks

When the barcode is scanned successfully, a photo is taken. For a QR code, the four corners can be approximated by first locating the “finder” and “alignment” patterns (the four squares on the corners of the QR code).

02 Feature Matching

Our algorithm focuses on corners and edges, and it generates a description of each feature which describes particular aspects of that corner or edge in a series of numbers. These features are then compared to the original image’s features, and the features which are most similar to one another are paired together. These matches allow us to see which points in the original image correspond to the points in the new image.

03 RANSAC Homography Estimation

A homography transform is a way of transforming an image to correct for perspective. Only four matching points are needed to define a homography. The RANSAC method is a way of finding a homography between the two images which will minimize the distance between the matches found in the previous step. It chooses a homography that minimizes outliers and maximizes inliers.

04 Similarity Optimization

Since the two images can be very similar, the four corners of the code must be determined with very high precision in order to achieve good results. The four corners are moved around slightly until a maximum similarity coefficient is found.

05 Skew/Rotation Transform

The four corners determined above are used to execute a homography transform and eliminate differences between the images caused by perspective.

06 Grayscale Conversion/Binarization

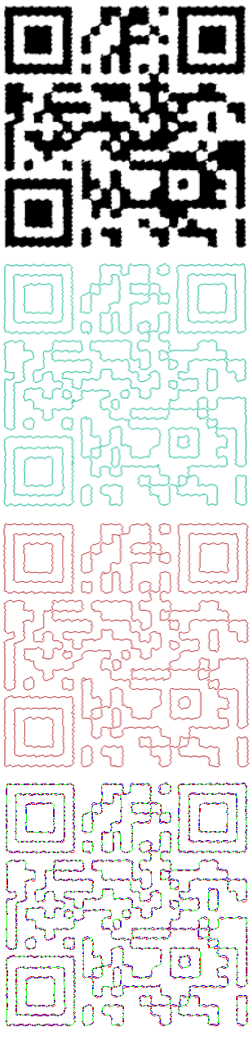
Convert the skew-corrected image to grayscale, and binarize the image by finding a threshold that minimizes intra-class variance of pixel values.

07 Edge Detection

Determine the edges of the barcode by finding where white and black pixels are adjacent to one another.

08 Correlation Coefficient Calculation

Determined by comparing the places where the images intersect to the places where they don’t. A higher amount of intersection means the codes are more similar to one another.



OUR KEY FEATURES

01 Unclonable Identifiers

Using our proprietary edge detection algorithms, we are able to create identifiers (i.e. 1D and 2D barcodes) that are designed with intrinsic, unclonable signatures.

02 Designed for Longevity

Our process is compliant with common manufacturing methods, such as laser etching, inkjet printing, thermal printing, and more.

03 Machine Readable

Assembly Line: Using an assembly line scanner, the tagged and indexed item can be verified as readable and be filed into a backend database to be used in lifecycle monitoring.

Product Verification: Using a common smartphone camera, the identifier can not only be read as a normal barcode, but the embedded information can be read and verified.

04 Lifecycle Monitoring

Product Manufacture: At the point of manufacture for the part, the identifier is etched onto the part and indexed into the database with manufacturer information and date and time of manufacture.

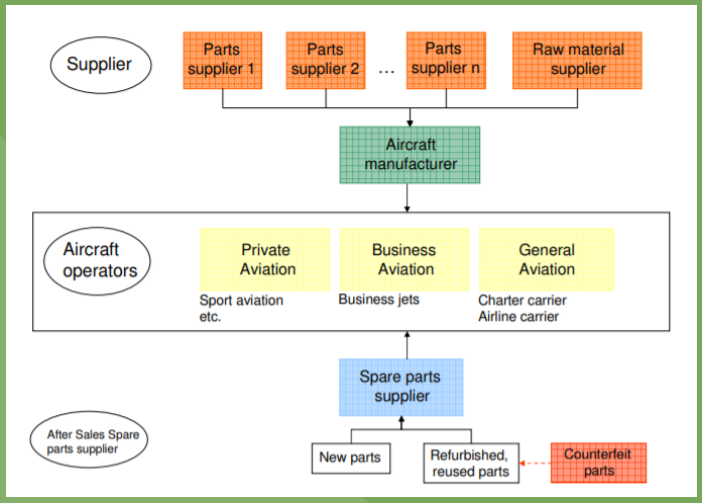
Product Supplier: A supplier of new or aftermarket parts can verify the authenticity of the sold parts and reject counterfeits before they reach their clients.

Product Operator: Before any product is installed or used, users can not only verify the authenticity of the part but also trace its path through the supply chain if there are questions.

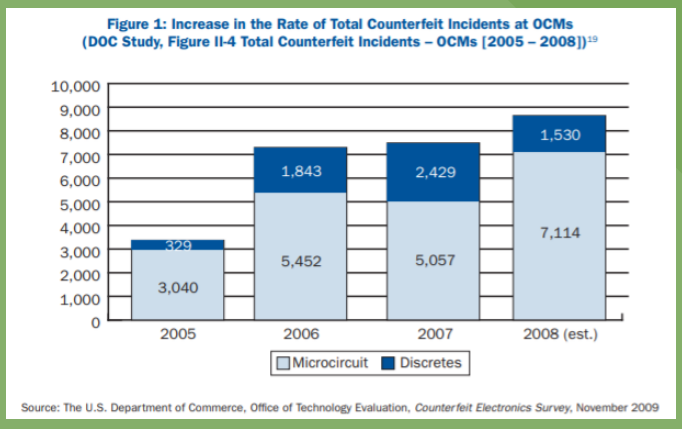
05 Constantly Improving

By implementing a flexible machine learning model within our algorithm, our results continuously improve over time as the number of analyzed identifiers grows.

PROBLEMS: AEROSPACE



2% of operational aircraft components are counterfeit.

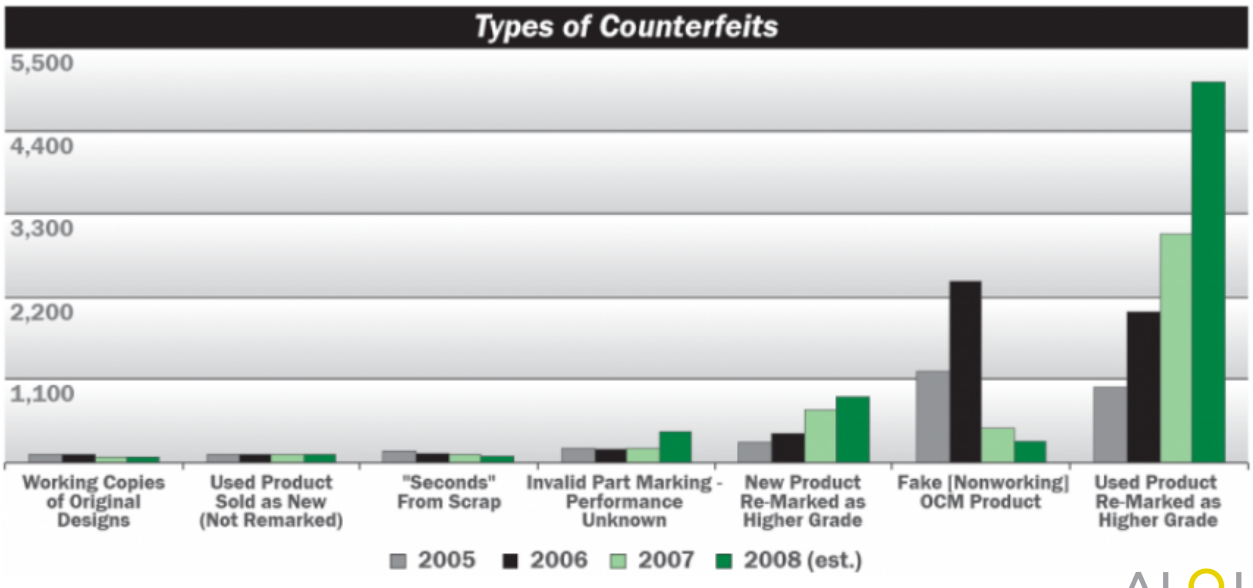


Since 2005, the number of annual counterfeits has increased significantly, with no signs of slowing.

Throughout the **product lifecycle**, components intended for use in aerospace applications are placed under stringent controls, with strong emphasis on the **verification of authenticity.**

Despite the existence of channels which ensure part quality and provenance, **counterfeits still enter into the supply chain** at various stages in the aircraft lifecycle, thereby introducing heightened risk for malfunction, crashes and loss of life.

One FBI estimate found that U.S. **businesses lose $200-$250 billion to counterfeiting on an annual basis.** This is caused by infiltration at every stage in product creation and maintenance, ranging from initial installation to downstream maintenance.



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OTHER INDUSTRIES

NUCLEAR MATERIALS MANAGEMENT

The ability to track decommissioned nuclear materials relies on the implementation of **tamper-proof materials** that can not only be **uniquely identified** but also **detect tampering efforts**. To this end, a technology that can meet both specifications has been developed that utilizes inkjet printer and/or laser etching forensics. This innovative process provides **security and strong assurance of tamper-proofing** to the employing country towards the aim of nuclear nonproliferation.

VOTING/BALLOT FRAUD

Without rigid safeguards to prevent **fraud, misuse, and voter intimidation**, ballot fraud—while it may occur sporadically—already **has affected the outcome of elections** in states and counties across the country.

Given the widespread societal and political shifts related to the **COVID-19** pandemic, it is anticipated that these issues will become **more widespread**, especially as more voters are expected to be **voting absentee**.

EXCISE TAXING

The collection of **taxes on cigarettes and alcohol** has been an ongoing struggle that involves an engaged regulatory body physically ensuring compliance. The current system has **no information associated with the stamps** and in many cases requires a document preparer to maintain compliance per the State's requirements. This leads to **increased costs** for administrative staff on both the distributor and State side in order to maintain this largely paper system.

Since the current tax stamp is **simply a paper stamp** with no tracking methodologies other than the distributor maintaining compliance manually, it can be **easily evaded** and moved through the **black market** by removing the stamp and affixing it to another pack of cigarettes.

HEALTHCARE/PHARMACEUTICALS

Healthcare counterfeiting comprises 10% of its global trade, causing serious downstream expenses and resource shortages. **Counterfeiting is already playing a major role in combatting the coronavirus (COVID-19) pandemic**, as equipment supply chains and vaccine development/distribution have been strained by increased demand. This is reflected in the growing prevalence of **counterfeit personal protective equipment (PPE), ventilators and even vaccines** as the pandemic develops. This entrance of counterfeit products into healthcare and pharmaceutical supply chains, made significantly worse by the spread of the novel coronavirus disease (COVID-19), has now introduced a need for authentication solutions, to **prevent end user harm.**

OUR CURRENT ROADMAP

Our immediate plan is to complete development and testing of a software which creates our unclonable identifiers as well as easily scans and reads these identifiers using a smartphone device.

Preliminary work shows that core functionality of our identifers is viable and accurate. We have completed 'works-like, looks-like' prototypes for initial beta testing in May/June of 2020. Full implementation is feasible at this time and only requires integration into existing systems.

There have been many studies on the affects of counterfeiting and they show that while the amount of counterfeiting may be relatively low, the implications have larger ramifications to worldwide supply chains. By tightening the supply chain, the number of potential counterfeit parts can be dramatically reduced and through the use of unclonable identifiers the attack space is reduced.

FEATURES

- Unclonable Identifiers
- Laser Etched
- Machine Readable
- Lifecycle Monitoring

MEMBERS

JAMES PIERCE III, MS
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MONTE BROWN
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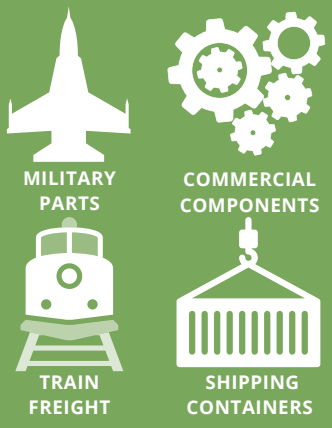
MARKETS



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GLOSSARY OF TERMS

Counterfeit - Whoever; intentionally traffics or attempts to traffic in goods or services and knowingly uses a counterfeit mark on or in connection with such goods or services, or intentionally traffics or attempts to traffic in labels, patches, stickers, wrappers, badges, emblems, medallions, charms, boxes, containers, cans, cases, hangtags, documentation or packaging of any type or nature, knowing that a counterfeit mark has been applied thereto, the use of which is likely to cause confusion, to cause mistake, or to deceive.

Machine learning - An application of artificial intelligence (AI) that provides systems the ability to automatically learn and improve from experience without being explicitly programmed.

Artificial neural network - Computing systems vaguely inspired by the biological neural networks that constitute animal brains and based on a collection of connected units or nodes called artificial neurons, which loosely model the neurons in a biological brain.

RANSAC - An iterative method to estimate parameters of a mathematical model from a set of observed data that contains outliers, when outliers are to be accorded no influence on the values of the estimates.

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