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Baggage screening using colour extraction algorithm and encryption of screened results

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Abstract

Threats to aviation security persist and continue to evolve. As a result, passenger and checked baggage security screening must continue to adapt to meet evolving threats and changes within the aviation industry. During peak hours in airports screeners have only a few seconds to decide whether a bag contains or not a prohibited item, and detection performance is only about 80-90%. This is a major susceptibility of air transport to security threats and illegal smuggling of goods. There is need for the aviation authorities to consider timely sharing of screening results. The use of ICT in electronic data exchange of information over open networks in particular requires implementation of Public Key Infrastructure to secure electronic exchange of information. The researcher developed a colour extraction tool that was integrated with encryption algorithm for securing screening results. The tool aims at providing a secure and timely mechanism of sharing travelers screening results with relevant authorities within the aviation eco-system.

Keywords: *Baggage Screening, Colour Extraction, Data Exchange, Distributed Application, Screening Process, X-Ray Scanner*

1. Introduction

International Air Transport Association vision of an "end-to-end passenger experience that is seamless, efficient and secure". The Association aims at offering passengers a frictionless airport process allowing the possibility to walk through the airport without breaking stride. The IATA Safety Connect program was designed to encourage active communication among airlines' safety and compliance managers regarding current and emerging potential safety issues. The safety program provides a conduit to exchange safety intelligence between peers to support a deeper industry understanding of current issues and employ mitigations used by others to collectively raise the bar on safety performance (IATA, 2022).

Some progress has been made in information sharing on passengers between airports; while data protection and privacy concerns are expressed, Technology is considered to be essential for forming the backbone for ensuring enhanced security and privacy for various applications in many other domains including the Internet of Things (IoT) eco-system (Miraz & Ali, 2018)**.**

In most airports in the world every air travel is preceded by passenger and baggage screening, the security checks of passengers and baggage in airports are regulated by extensive regulatory system. According to DHL (2018), security technologies can potentially improve efficiency in aviation eco-system by greatly reducing bureaucracy and paperwork. technology can help alleviate many of the frictions in global trade logistics including procurement, transportation management, tracking luggage's, customs collaboration and immigration verification processes.

1.1. Baggage Screening Process

According to World Custom Organization (2021), there are different security and custom rules and regulations to follow in different countries. Baggage screening is a security and custom requirement in aviation industry, Baggage Screening Process (BSP) involve screening of bags is carried out automatically by an X-Ray screening machine. Here, trained operators examine the detailed images of these bags.

Explosive Detection Systems (EDS) were developed based on X-ray imaging and computed tomography through elastic scatter X-ray (comparing the structure of irradiated material, against stored reference spectra for explosives and drugs (Riffo & Mery, 2018). This results can be classified either as "bad" or "good" outcome, with a "bad" outcome indicating that there may be a prohibited item in the individual's bag. As the library expands, the algorithm is able to learn and moves us towards completely automatic identification of weapons, explosives, and prohibited items (Karoly, 2017).

Sompagnimdi and Hurter (2017), found that, X-ray scanned image only contains densities and cannot display the material original colours. The standard colour visual mapping uses three different colours (orange, green, and blue) to display the data density. Orange colour corresponds to low density (mainly organic items). In opposition, blue colour is used for high density items (e.g. metal). In the case of X-ray systems, green colour corresponds to the superposition of different kinds of materials or average density materials as depicted in the Figure 1 below.

Figure 1: X-ray scan with the 3 standard colours (orange, green, and blue). (Sompagnimdi & Hurter, 2017)

Advanced generation X-ray scanners are now using six colours to differentiate different materials that are in the baggage as indicated in Figure 2. The Colour information helps security officers to recognize the objects and it can be used as an extra feature for automatic recognition systems to achieve higher recognition rates (Vukadinovic & Anderson, 2022).

Material class	Examples	Threads
Background		
Light organic	Wood, Fabric	Explosives C4, Trotyl
Heavy organic	Plastics, Glass	Drugs, Heroin, Cocaine
Non-organic	Aluminium, Salt	Gunpowder
Metals	Iron, Steel, Brass	Guns, Bullets
Heavy metals	Silver, Gold	Jewellery contraband
Not-penetrable	Lead	Threat hiding

Figure 2: Material pseudo-colours and its classes used widely in the X-ray security scanners (Benedykciuk, Denkowski & Dmitruk, 2020)

1.2. Statement of the research problem

The X-ray technologies have become an important tool in airport security, which has become the chief application for these techniques outside the medical sector. Enhancing the X-ray/CT image the human operators need to visually inspect, and secondly, by providing automated detection of objects in the image. State-of-the-art algorithms typically focus on image enhancement and image understanding. One of the most used image enhancement methods is pseudo-colouring ((Vukadinovic & Anderson, 2022).

Riffo and Mery (2018), found that, during peak hours in airports screeners have only a few seconds to decide whether a bag contains or not a prohibited item, and detection performance is only about 80-90%. This is a major susceptibility of air transport to security threats and illegal smuggling of goods. There is need for the aviation authorities to consider screening results data exchange in cooperation with customs and other appropriate authorities such as embassies.

Data exchange system should communicate in a timely manner especially for high-risk luggage's and items that require passengers to fill in custom declaration forms. A key challenge is in ensuring that information is passed on to relevant agencies responsible for aviation security, customs and to airlines in a secure and timely manner. This requires more effective coordination between relevant actors in aviation eco-systems: airlines, airport operators, customs, embassies and public authorities in aviation eco-system (CSES, 2023).

The use of ICT in electronic data exchange of information over open networks in particular, requires implementation of Public Key Infrastructure to secure electronic exchange of information. The researcher intends to develop a framework and a colour extraction tool for analyzing baggage and sharing screening results with relevant authorities within aviation eco-system using a hybrid cryptosystem.

1.3. Research objective

The main objective of the study was to develop a framework and a colour extraction tool for analyzing baggage and encryption of screening results using AES and RSA Algorithm.

2. Methodology

The research approach that was adopted in this study will be Design-Science Research (DSR. The research process for this study was divided in three phases that aim at achieving research objectives. The first phase involved need assessment, second phase was designing the proposed tool and the third phase involved testing the tool to determine its effectiveness. The tool was developed using PHP and MySQL Database.

2.1 Design-Science Research

Design-science is a complement to the natural science approach and is particularly relevant for contemporary IS research because it helps researchers confront two of the major challenges of the discipline: the role of the IT artefact in IS research and the level of professional relevance of IS studies (Arnott & Pervan, 2012). Developed tool is complete and effective when it satisfies the requirements and constraints of the problem it was meant to solve.

2.2 Encryption Algorithms

The public key can be known by everyone and is used for encrypting messages. Messages encrypted with the public key can only be decrypted in a reasonable amount of time using the private key. One party uses a public key and the other party uses a secret key, known as the private key to decrypt the message. Public key encryption algorithm uses a public key of PU= (e, n) and private key of PR= (d, n). Scanned images and results will be encrypted by enhanced model of Advanced Encryption Standard to possess good level of security and better range of image encryption (Devashish, Lakshmi & Jaiswal, 2016).

Advanced Encryption Standard (AES) encryption system is symmetric in group, there are three kinds of key length in this way of encryption: 128 bits, 196 bits and 256 bits, packet size is all 128 bits. AES algorithm not only for security but also for great speed. Both hardware and software implementation are faster still (Mahajan & Sachdeva, 2013). According to Zhang and Qunding (2015), the process of encrypting image with AES algorithm requires conversion of digital image into a binary matrix. Decryption process is the inverse of the encryption process. In the process of the image transmission it will be not susceptible to tampering or eavesdropping. The process of image encryption based on AES is shown in Figure 3 below.

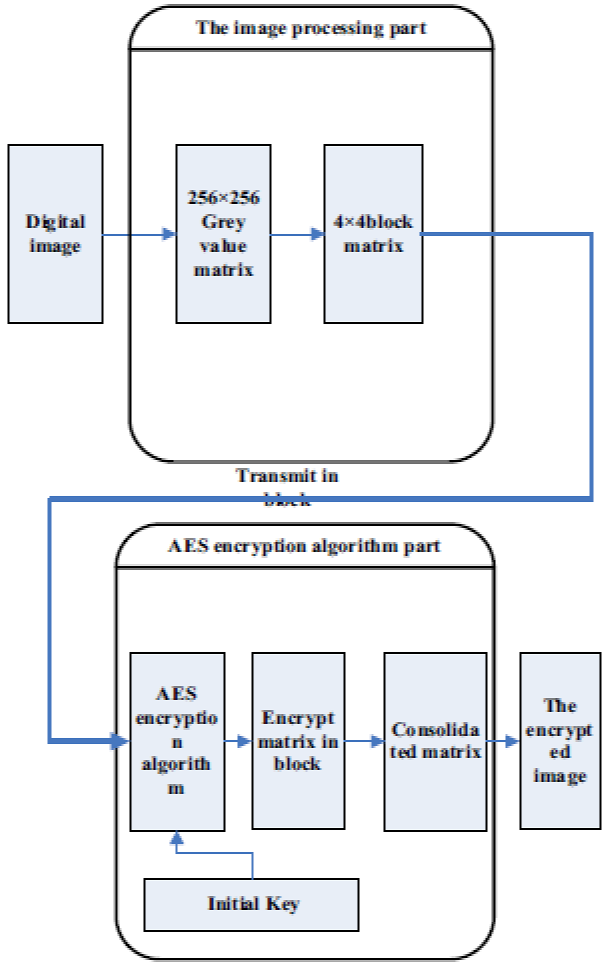


Figure 3: The process of image encryption based on AES (Zhang & Qunding, 2015)

2.3 Generation of Public and Private Key pair using RSA Algorithm

The RSA algorithm is a public key cryptosystem which involves three steps: key generation, encryption and decryption. Key generation: First choose two distinct prime numbers p and q and then compute n=pxq where n is the modulus for the public key and the private keys. $\varphi(n) = (p - 1)(q - 1)$. Next compute Choose an integer e such that $1 < e < \varphi(n)$ and GCD $(e, \varphi(n)) = 1$. The pair (n, e) is the public key. The private key is a unique integer d obtained by solving the equation $e \equiv 1(\mathrm{mod}\varphi(n))$. Encryption method: is used for encrypting an image or text by using public key. the messege (m) is presented as pixels in the range from 0 to 255. The text is encrypted using the public key (n, e) from the equation c = m power e mod (n). Decryption method: The text or image is decrypted using the private key (n,d). m = c power d mod (n) (Alsaffar, Almutiri, Alqahtani & Alamri,2020).

2.4 Architectural Model

Figure 4 below depicts the architectural model for this study. The process starts at check in followed by screening process module. Baggage results are flagged as green if they satisfy country of origin rules and regulations. Red flag indicate the traveler or luggage requires further clearance. The RSA Algorithm was used to create a private- public key pair based on destination address public key. The scanned images and the results were encrypted using AES algorithm. The encrypted results are sent in the distributed databases.

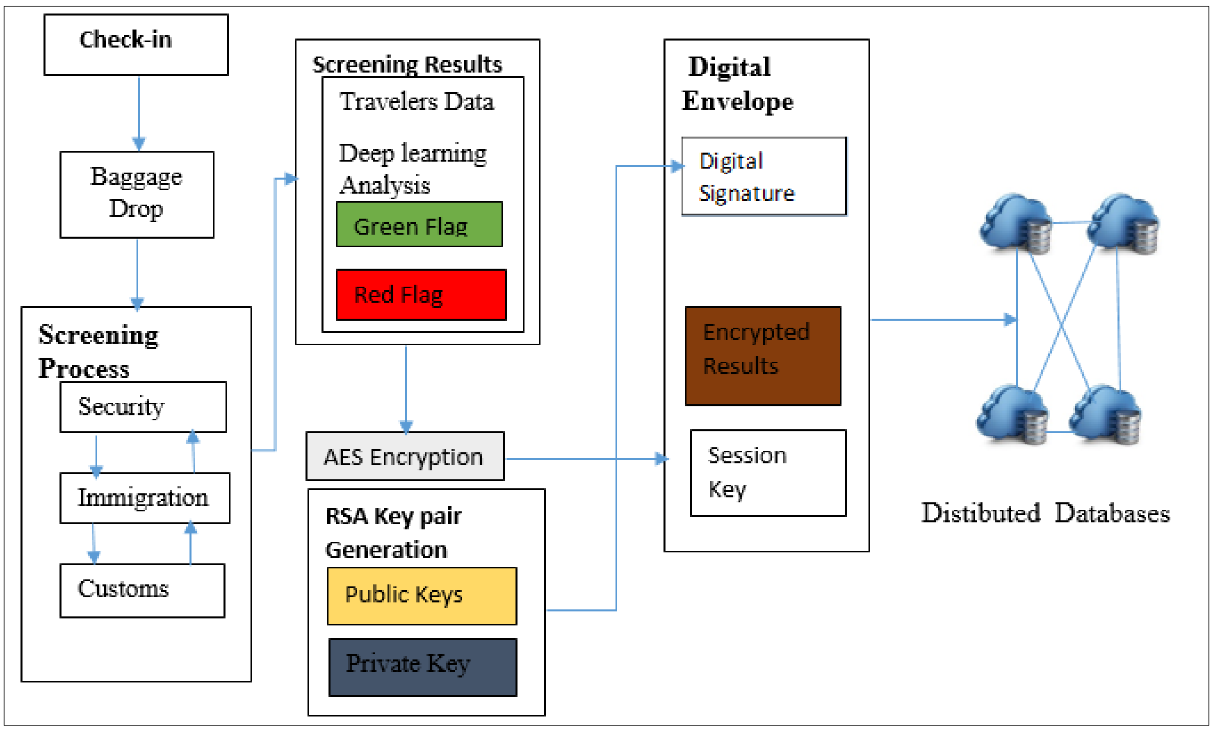


Figure 4: Architectural model for baggage screening and securing screening results

3. Results and discussion

This section provides key results for this study. The application results and findings were classified into two Baggage X-Ray image colour extraction algorithm, barcode generation algorithm, application for baggage results exchange system using a public blockchain and performance testing results.

3.1 Babbage Image Colour Extraction Algorithm

The standard colour visual mapping for the baggage X-ray scanner uses three different colours (orange, green, and blue) to display the data density. Orange colour corresponds to low density (mainly organic items). In opposition, blue colour is used for high density items (e.g. metal). In the case of X-ray systems, green colour corresponds to the superposition of different kinds of materials or average density materials. The image colour extraction class pulls the most common colours out of an image file. The Image Colour Extraction algorithm class pulls the most common colours out of an image file. The colour values are in hexadecimal.

The researcher added some enhancements allow users to select the quantization delta and to show the colour percentages. Green flag is assigned when the percentage of the orange and green hexadecimal colour values is at 75% and red flag if the percentage of blue colour exceeds 25%. Figure 4 below show the implementation of the module using the colour extraction algorithm.

3.2 Screening Process Module using colour extraction algorithm

The system allows authenticated users to access and upload scanned image files. After baggage screening process, the system automatically assigns a green flag or red flag depending on the sum of percentages**.** Screening officers can comment on the traveller's luggage by giving a luggage description as well as some comments on the luggage. Figure 5 below shows the baggage processing interface.

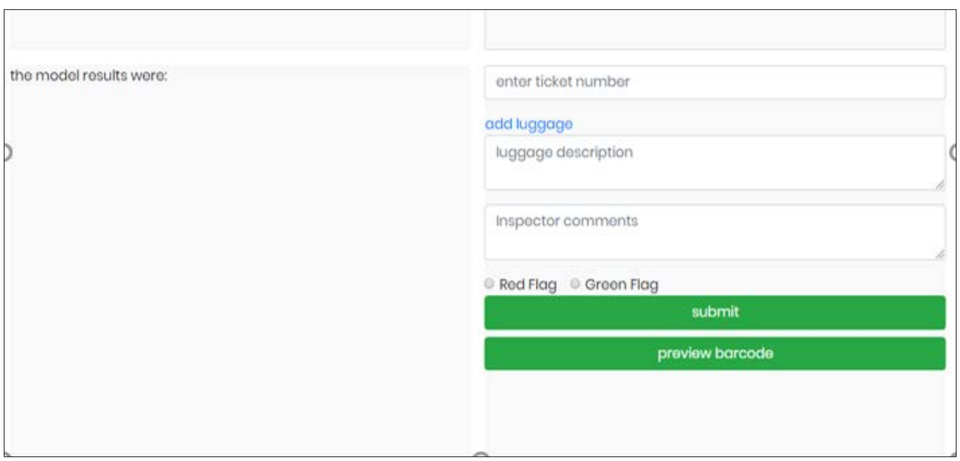


Figure 5: Luggage processing interface

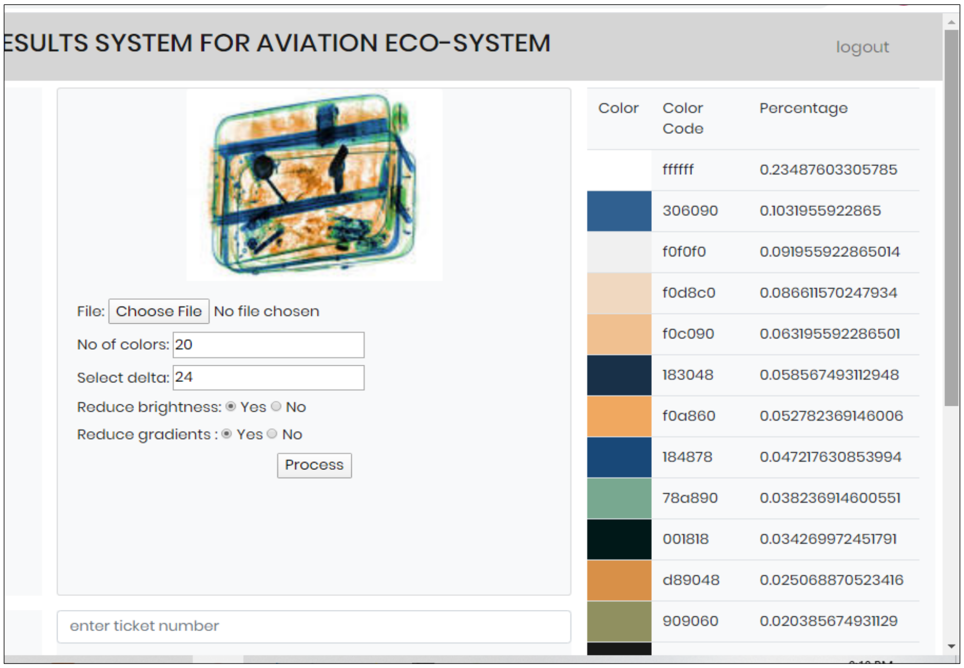


Figure 6: Baggage Screening results using colour extraction algorithm

Table 1: Extracted colour codes and percentages

Sn	Colour codes	Percentages
1	Ffffff	0.234
2	306090	0.303
3	F0f0f0	0.091
4	F0d8c0	0.086
5	F0c090	0.063
6	183048	0.058
7	F0o860	0.052
8	184878	0.045
9	78o890	0.038
10	001818	0.034
11	D89048	0.025
12	909060	0.030

The table 1 shows the extracted colour codes by the algorithm. Colour code blue in serial no 2 had a 0.303 percentage.

The module allows the security officer to generate a unique barcode usig the traveller's ticket number and baggage screening results. Most of barcode scanners support the following common barcodes: CODE39, CODE128, Interleaved25, EAN8, EAN13, PDF417 and QRCODE. The researcher used **Code 128**. It can store any character of the ASCII 128-character set and hence is the most suitable barcode symbology for use in the supply chain. Figure 7 below shows the preview of the barcode.

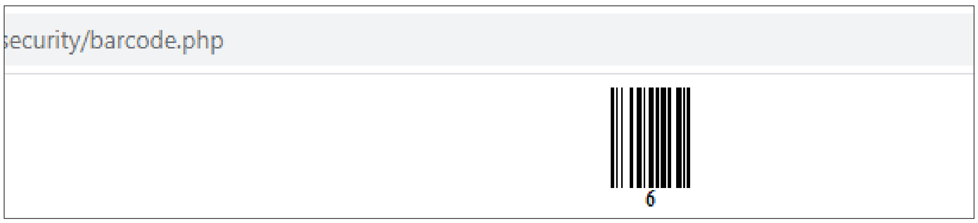
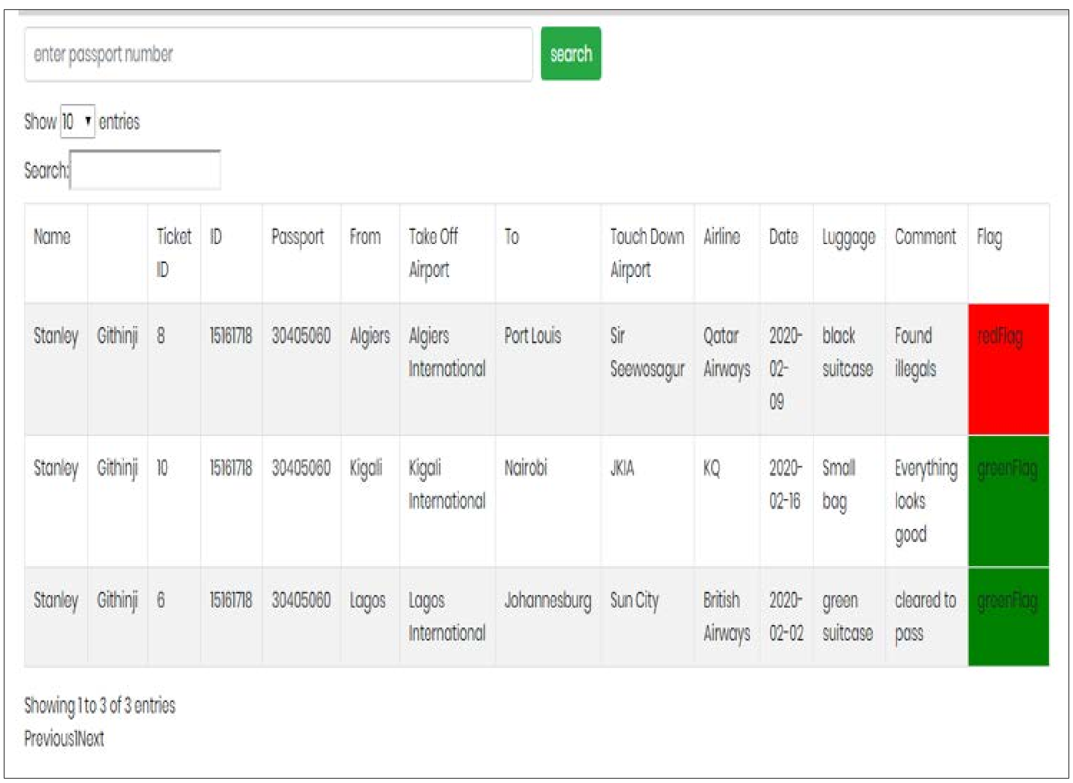


Figure 7: Barcode Preview



enter passport number search

Show 10 entries

Search:

Name		Ticket ID	ID	Passport	From	Take Off Airport	To	Touch Down Airport	Airline	Date	Luggage	Comment	Flag
Stanley	Githinji	8	15161718	30405060	Algiers	Algiers International	Port Louis	Sir Seewosagur	Qatar Airways	2020-02-09	black suitcase	Found illegals	redFlag
Stanley	Githinji	10	15161718	30405060	Kigali	Kigali International	Nairobi	JKIA	KQ	2020-02-16	Small bag	Everything looks good	greenFlag
Stanley	Githinji	6	15161718	30405060	Lagos	Lagos International	Johannesburg	Sun City	British Airways	2020-02-02	green suitcase	cleared to pass	greenFlag

Showing 1 to 3 of 3 entries

PreviousNext

Figure 8: Travellers baggage screening results

3.3 Performance Testing Results

Performance testing analyses if the performance parameters like response time , dependableness, load capability among others to determine if the tools meets the needs of the customer (Srivastava, , Kumar, & Singh, 2021). It is essential to perform testing of a technological artefact because defects and errors committed during the development phase can be identified, rectified and offer assurance of the quality of the product by showcasing on the effectiveness of software artefact (Sondare, 2017). The application had a performance rate of 98 % and Structure attained 87 %.

The system had attained a load time of 1.4s as shown in Figure 9.

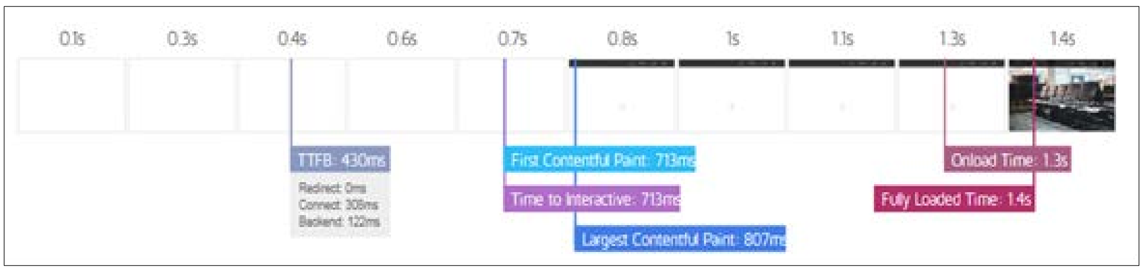


Figure 9: System load time

The load time of the system can be improved by eliminating render-blocking resources which could provide potential savings of 377ms and Potential savings of 900KB if a static cache policy is implemented.

4. Conclusion

This research work provides a mechanism for analyzing baggage using colour extraction algorithm and secure mechanism for result sharing by ensuring that information is passed on to relevant agencies responsible for aviation security, customs, embassy's and to airlines in a secure and timely manner. The colour extraction algorithm provides a flexible solution for remote inspection of scanned baggage x-ray images.

This research recommends integration of machine learning algorithm into the application to offers ways of automatically screen for prohibited items including explosives, firearms, sharp objects, etc. Deep (or machine) learning uses advanced algorithms that pair shape identification with material properties and density measurements, then compares that against a very large library of scanned items. There is also need to develop decentralized smart contract that will make transactions and other business processes within the framework more secure, efficient and cost-effective, thereby reducing transaction costs.

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