A MIDSEM / FINAL REPORT

ON

COMPUTER VISION BASED ANTI-COUNTERFEITING SOLUTIONS FOR SUPPLY-CHAIN INDUSTRY

BY

MEGHA MANOJ 2020A7PS0016U

AT

BOVA IT
DUBAI, UAE

A Practice School – II Station of

BITS Pilani, Dubai Campus
Dubai International Academic City, Dubai
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(January 2024 – July 2024)

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Abstract (Max 200 words):

Counterfeiting has become a prevalent act within the supply chain industry where tons of luxury items are susceptible to losing their value due to the hike in production of fake products. Every day, thousands of products are manufactured from raw materials to branded products which are purchased by customers at retail stores. Although security measures have been implemented for tackling counterfeiting, counterfeiters have been equally competent at cloning the technology for their malpractices. Their ability to look for loopholes within the implemented measures makes them experts at decrypting the stored product information and creating replicas of the actual product for earning money. In light of such practices, brands have attempted to devise new solutions by combining existing security measures with rising security techniques to attain maximum possible security. To refine and develop improved secure systems, this project focuses on the integration of computer vision and machine learning to generate a unique solution that focuses on the optical characteristics of the security tag.

Signature of Student **Signature of PS Faculty**

Date: 28 /06/2024 **Date:**

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Megha Manoj
2020A7PS0016U

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Chapter -1 About the company

1.1. BOVA IT

BOVA InfoTech is a technology startup which focuses on offering digital solutions for the retail industry with a heavy focus on blockchain and sustainability. The enterprise aims to create affordable applications which cater to retail services at all levels. Their main focus is to empower their app-users with the ability to manage their expenditure as well as their trust in their preferred retailers in an efficient manner.

1.2. Klipit

BOVA IT is in their pre-launch phase for their product klipit, an electronic receipt management app which allows its users to monitor their expenses and purchases. It utilizes database management on blockchain to create a vigorous yet easy to use software. The application aims to create a seamless transaction of receipts from the point-of-sales system (POS) at retail stores to the customers' account on klipit using a special id encoded in a QR code which is presented at the POS for activating the procedure.

1.3. Anti-counterfeiting concepts

The goal of the practice school-based internship is to assist BOVA IT in the research and development of an anti-counterfeiting solution which is exceeds security levels of 90% by integrating A.I concepts with blockchain.

Chapter -2 Supply chain management

Supply chain management (SCM) refers to the production of goods from raw materials to finished products that are available to consumers in stores. SCM consists of monitoring various phases of production, packaging and transportation which often involve several sub-phases within them. Depending on the type of goods produced, businesses often have customized and varied supply chain strategies to control the expenses and demands for different products.

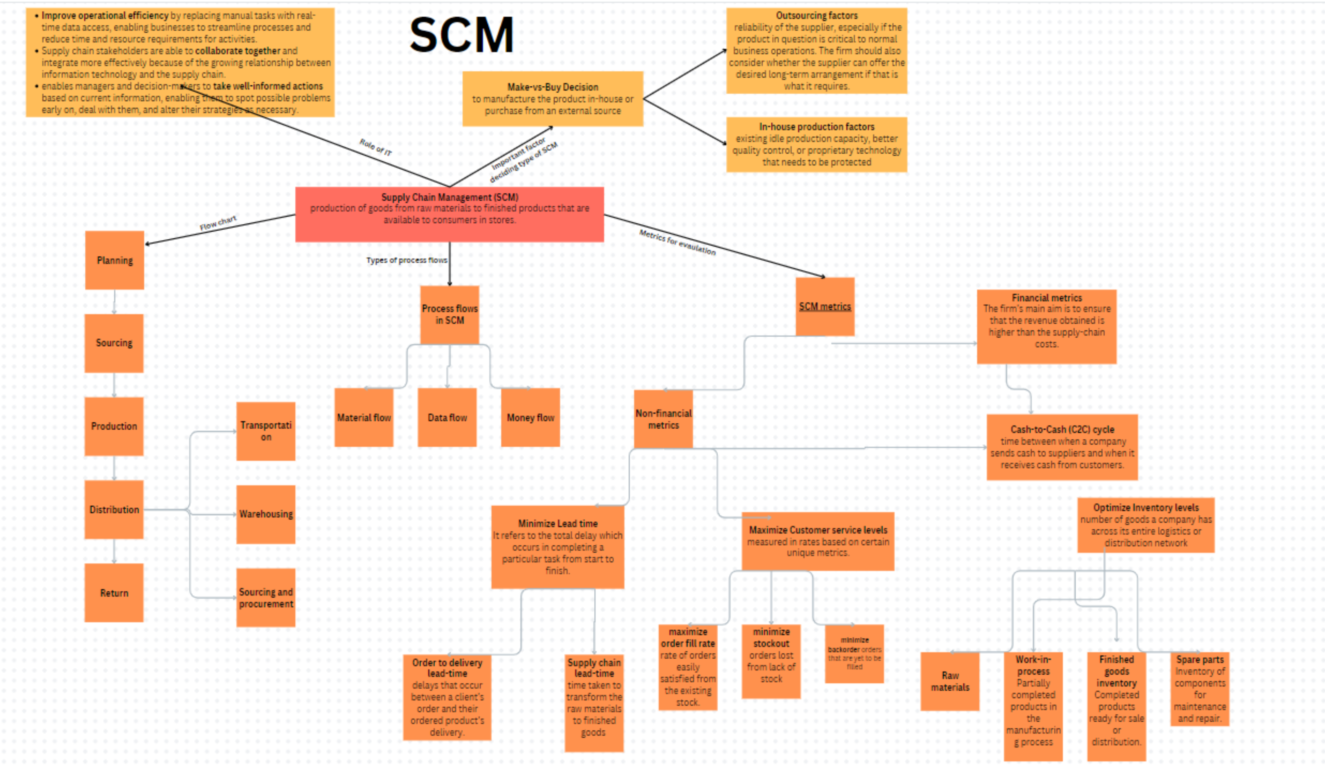

Figure 1 Generic Supply chain management system

2.1. Stages of supply chain management

The supply chain process consists of several elaborate stages which are vital for ensuring the smooth functioning of the implemented supply chain system:

2.1.1. Planning

The planning stage involves creation of a strategy that yields maximum profit with minimal costs while addressing the demands of the consumers. Every considerable factor is decided via research and analysis for future implementation based on the type of product the brand or company wishes to produce.

2.1.2. Sourcing

Identifying raw material supplies and forming a relationship with them. This stage accounts for all aspects of obtaining the raw materials from the sources- pricing, quantity, delivery, etc.

2.1.3. Production
The production stage involves acts of manufacturing, packaging and pre-distribution preparation of goods. Production stage often consists of worker productivity evaluation and quality control of goods.

2.1.4. Distribution
Once the products are ready, orders from clients are accepted and the goods are distributed to warehouses through designated modes of transport. The logistics system involved in the process is a whole system of its own.

2.1.4.1.Transportation
Decisions on the primary mode(s) of transportation are finalized after a thorough examination of long-term decisions for outsourcing the product. These decisions also reflect how the flow of goods is monitored and which routes offer optimal costs with on-time delivery. The route information is then relayed to the drivers and dock-level personnel.

2.1.4.2.Warehousing
A vital part of the SCM process, warehouse management systems are deployed to direct the storage of products. When selecting a warehouse, the number of stock-keeping units within the warehouse plays an important role. Other factors which come into play include the type of orders processed and the demands put forth by the clientele.

2.1.4.3.Sourcing and procurement
There are 2 types of sourcing when it comes to SCM- internal and external. Internal sourcing involves all operations being handled by the company themselves with specific departments for each task. On the other hand, external sourcing requires the company to form relationships with other independent firms which requires deliberate decision making and awareness of the external parties' method of operations.

2.1.5. Return
The return stage makes up the final stage of the supply chain process. This stage is implemented at the retailer store or after purchase by the customer. Through the return stage, the retailer or customer is able to reimburse or return the purchased/ ordered goods which are deemed defective or do not meet the desired quality standards. For facilitating the return procedure, brands/ companies often have set up online communication procedures or call centers where the concerned party can get in touch with the appropriate point of contact- usually the distributor, manufacturer or the brand.

2.2. Systematic procedures of SCM
On the basis of a plethora of factors, there exists several procedures within the SCM to ensure a smooth flow in tracking of different factors such as finances and production materials. An efficient flow within the SCM is capable of positively influencing the brand’s reputation.

This enables the system to quickly respond to any unforeseen circumstances which may disrupt task execution:

2.2.1. Material flow

Material flow refers to the tracing the movement of materials from raw materials to finished products. It also includes monitoring the location and storage of the supposed product at warehouses and stores till it is available to the customer.

2.2.2. Data flow

Data flow stands for the information that is transferred amongst designated individuals in the form of contracts, schedules, complaints, etc. These enable SCM to have consistent and clear communication for its proper functioning.

2.2.3. Money flow

Just as a business involves various expenditures ranging from cost of raw materials to cost of transportation of goods. There are several costs involved in production as well as maintenance of the SCM. Hence it is important to monitor the financial transactions and modes of payments involved within the SCM processes.

2.3. SCM performance metrics

As part of ensuring that the supply chain is at its best performance, companies utilize several metrics to evaluate the functioning of the SCM. These metrics allow the company to refine their procedure and offer better services. Primarily, there are 2 types of metrics:

2.3.1. Financial metrics

The costs involved at each phase of the supply chain is measured via certain financial metrics which allows incorporation of minimalistic costs and efficient production

2.3.2. Non-financial metrics

These are certain formula-based metrics which determine the quality and quantity of the production and order management:

2.3.2.1. Lead time

Lead time refers to the total durational delay which occurs in completing a particular task from start to finish. There are 2 important kinds of lead time- supply chain lead time and order-to-delivery lead time. Supply chain lead time refers to the time taken to transform the raw materials to finished goods while the latter refers to delays that occur between a client’s order and their ordered product’s delivery. Through accurate estimates of lead time, companies can predict future demands for replenishing and controlling their inventories.

2.3.2.2. Customer service levels

Customer servicing is measured in rates based on certain unique metrics. For maintaining an optimal service level, the company must maximize order fill rate (rate of orders easily satisfied from the existing stock), minimize stockout (orders lost from lack of stock) rate, and minimize backorder (orders that are yet to be filled) levels.

2.3.2.3. Inventory levels

The expenses surrounding inventory management has a significant impact on the overall SCM costs. There are 4 types of inventories in SCM:

- Raw materials
- Work-in-process- Partially manufactured completed products.
- Finished goods inventory- Finished products ready to be shipped for sale or distribution.
- Spare parts- Inventory of components for maintenance and repair.

2.3.3. Resource Utilization

Resource utilization in supply chain management involves efficiently allocation and optimization of labor, equipment, facilities, and other resources to support production, distribution and transportation activities. Effective resource utilization helps enhance productivity, reduce costs and improve overall supply chain performance.

2.3.4. Supplier market assessment

Supplier market assessments can be defined as the research and analysis involved in understanding current consumer needs and up-to-date marketing methodologies implemented for faster production and sale. This also comprises utilization of the latest technologies.

2.4. Supply chain strategy

There are 2 traditional strategies in SCM- in-house production and outsourcing produced goods. The former strategy consists of all phases of production being handled by the brand while the latter involves buying orders from certain manufacturers and handling its distribution to several locations. A brand/company chooses its SCM strategy on the basis of its product, budget and many other regional and international factors:

2.4.1. Business strategy

Whether the product is going to be outsourced, any type of maintenance (machinery or product related) is required and what kind of technical skills are required for the production of the product.

2.4.2. Risks

The quality of service and reliability of the external sources matter a lot in outsourcing. Risks associated with the production facilities being abroad or importing the product, errors in manufacture and packaging during bulk production. Other problems which can arise within the SCM could include the failure of payment gateways during monetary transactions and other IT related issues such as discrepancies in entered data, glitches in websites, etc.

2.4.3. Economic factors

Economic factors such as labor costs, material costs, capital expenditures, etc. come into play. Hence, it is vital for the company to choose its outsourcing partners carefully. Although both strategies are widely applied within supply chains, several brands use a mix of the two strategies combined with technical advancements to speed up the SCM phases.

Chapter -2 Counterfeiting in the Supply chain industry

As brands become popular and valuable, their production costs increase to meet the large demands of its consumers and at times the price of the product may rise as well. The act of counterfeiting has become a commonplace activity within the supply chain industry of luxury items. This chapter focuses on the various weaknesses of present-day anti-counterfeiting measures which counterfeiters exploit for their benefits to sell fake luxury products at extreme prices.

2.1. Introduction to Counterfeiting

Counterfeiting refers to creation of replicas of high-quality products with the intention of selling these fakes at a high price for financial gain. These products are created from cheap materials which resemble their luxurious original's composition. Counterfeited products exist at several grades depending on how closely they resemble the actual product. As the grade rises, it becomes very cumbersome to recognize which product is the real one.

Counterfeiting poses adverse damage to the brands as it creates a sense of distrust and diverts loyal customers of the brands by diminishing their brand image. Hence, it is quite important for brands to protect their products' authenticity. Currently, many brands have attempted to make their products' journey transparent by showcasing their supply chain procedure to the public.

2.2. Traditional methods of anti-counterfeiting

Anti-counterfeiting refers to prevention of cloning of genuine items. Many brands seek to tackle counterfeiting via tagging their products with unique identifiers. Some of the most frequent types of security tags used are as follows:

2.2.1. Barcodes

Barcodes consist of several long stripes where each stripe represents a certain character of the code it carries. It is one of the cheapest security methods which can store more than 1000 characters depending on the type of barcode used. There are several international standards set in place with respect to barcodes- its sizing, the formatted information it carries, etc. Their advantages include being easy to produce and scan for information which also provides grounds for their weaknesses. Barcodes are readable by anyone who possesses a barcode reader or barcode reading application which makes it very easy to steal the information present within them.

Figure 2 Barcode

2.2.2. Radio-Frequency IDentification (RFID) tags

RFID tags are much more reliable sources for security purposes than barcodes as they function on the basis of radio waves. It requires special reader machines, making it much more difficult to access the data present within them. RFIDs comprise of coils which carry information that transmit data upon encountering certain frequencies. These frequencies are difficult to obtain without the required reader. Although RFIDs are more advantageous in comparison to barcodes, they also have a set of disadvantages. A RFID tag can easily be scrambled manually rendering it useless and undetectable; if held beyond a certain distance. Additionally, setting up RFIDs involve a large expenditure making it accessible only to large brands.

Figure 3 RFID tag

Figure 4 QR codes and data matrix

2.2.3. Quick Response Codes (QR) and data matrix

QR codes and data matrices are barcodes in a two-dimensional format. They are cheap and easy to generate. Much like barcodes, they are easy to read by all types of scanners on the basis of certain indicators present within their patterns. QR codes tend to have more disadvantages than advantages in comparison to the other tagging techniques due to their easily accessible information and their environmental exposure as it renders them susceptible to damage. Additionally, their sizing varies depending on the number of characters they carry hence making them more complex for data extraction in general.

2.2.4. Holographic labels

Holographic labels refer to security stickers attached to products or its packaging with the intention of product authentication. There are different types of holographic labels depending on their patterns and the holographic effect present on them. Due to their delicate nature, they have both pros and cons which are ambivalent to each other. These labels are easily damaged and difficult to read by scanners due to the

Figure 5 Holographic label

reflective property of the labels. They are also vulnerable to environmental damage due to their composition of delicate plastics as well.

2.3. Emerging trends for anti-counterfeiting

In light of the previously listed constraints of traditional security measures, several brands have attempted to create their own methods of security by combining various technologies which can assist them in protecting their brand's authenticity.

2.3.1. Unclonable patterns

Several supply chain companies have come up with unique patterns generated using Artificial Intelligence (AI) to showcase the products' authenticity. An appropriate example of this strategy is the anti-counterfeiting service offered by Checko.io, who have generated tags consisting of AI-generated 3d patterns of ground cracks with a special chemical layer, which are unique for each product. These 3d patterns along with designated product QR codes are verifiable via smartphone technology.

Figure 6 Unclonable patterns

2.3.2. Secure QR codes

Secure QRs refer to patented specialized QR codes which consist of a central noise pattern which renders them difficult to clone while being scannable via readers. Certain algorithms are implemented which ensures that the QR has not been cloned via Application programming interface (APIs) as done by Scantrust technologies. However, this does not ensure that the information within the QR is not cloned; which allows recreation of the QR code- possibly without the pattern.

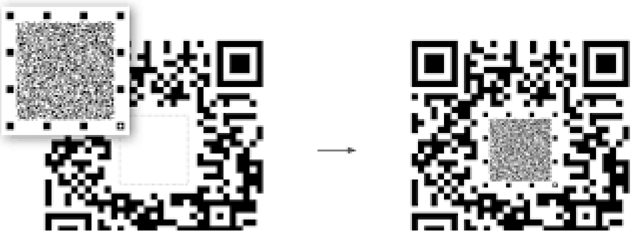

Figure 7 Secure QR codes

2.3.3. Blockchain based verification

One of the most popular yet emerging security measures is the integration of blockchain technology into SCM. Due to the indestructible nature of Blockchain, a decentralized ledger,

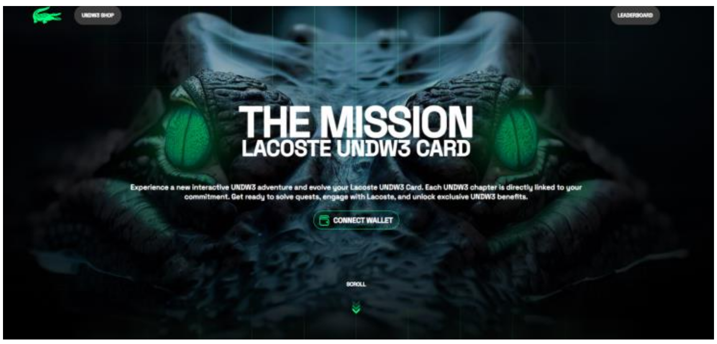

Figure 9 Lacoste UNDW3 NFT

Figure 8 LVMH Trunk NFT

storing product information reaches its highest point of secureness. Since blockchain involves heavily restricted access it is impossible to hack the database. Many luxury brands, such as Lacoste and Louis Vuitton have made use of Non-Fungible Tokens (NFTs), unique tokens which are created and present on blockchain, to increase customer engagement via online events as well as ensure genuineness of their products. This not only offers the customers an overview of the product's journey but also serves as an incentive for a loyalty program and privileged access for their frequent customers.

2.3.4. Quantum dots

Quantum dots refer to minute particles which possess semiconductor properties that are integrated into QR codes or directly into the products to ensure prevention of counterfeiting. These particles often contain fluorescent elements to verify that the QR code is genuine and are minuscule in size which makes them difficult to retrieve. They are embedded into the security tag or product label via unique printers making their location difficult to detect by the counterfeiter.

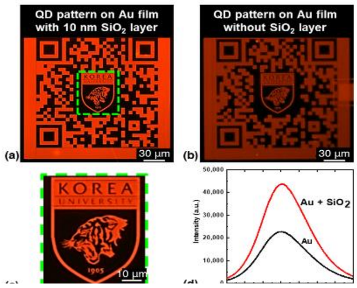

Figure 10 Quantum dots

2.3.5. Digital fingerprinting

Digital fingerprints are unique patterns or logos which are imprinted upon the labels for ensuring that the product label is not copied. They are often invisible to the naked eye unless exposed to certain spectrums of lights or scanners. These fingerprints implement the art of cryptography to ensure that the watermark itself is not copied. Digital watermarking is generally applied to digital documents but have recently been implemented within the supply chain industry to ensure that product packaging is not cloned.

Figure 11 Digital fingerprint

Chapter -3 Supply chain management case study Walmart

The following chapter provides an overview of the brief procedure implemented by Walmart for their supply chain management. It shines light upon its product authenticity strategy using Blockchain and AI.

3.1.Introduction to Walmart's SCM

The multinational retail corporation Walmart, is an apt example of the hybrid make-vs-buy decision. The organization sources its products both locally and internationally while operating approximately 10,500 stores and clubs in 20 countries and eCommerce websites. The retail outsources about 90% of its production due to which they have set up a management system which focuses primarily on its distribution phase and inventory management at its warehouses. Some of these warehouse implements a system which combines automation via robots with its human workforce for packaging and monitoring shipments, labeling and distribution to its stores along with deliveries meant for its e-commerce orders.

Figure 12 Walmart store

Walmart's warehousing is based on the kind of goods which it receives. The goods upon arrival/ docking are directed to specific distribution centers based on their perishability, type of product and special requirements. The brand allows the manufacturers to entirely handle the production and distribution of certain products which require high security such as jewelry and drugs as well to ensure maximum security of the goods.

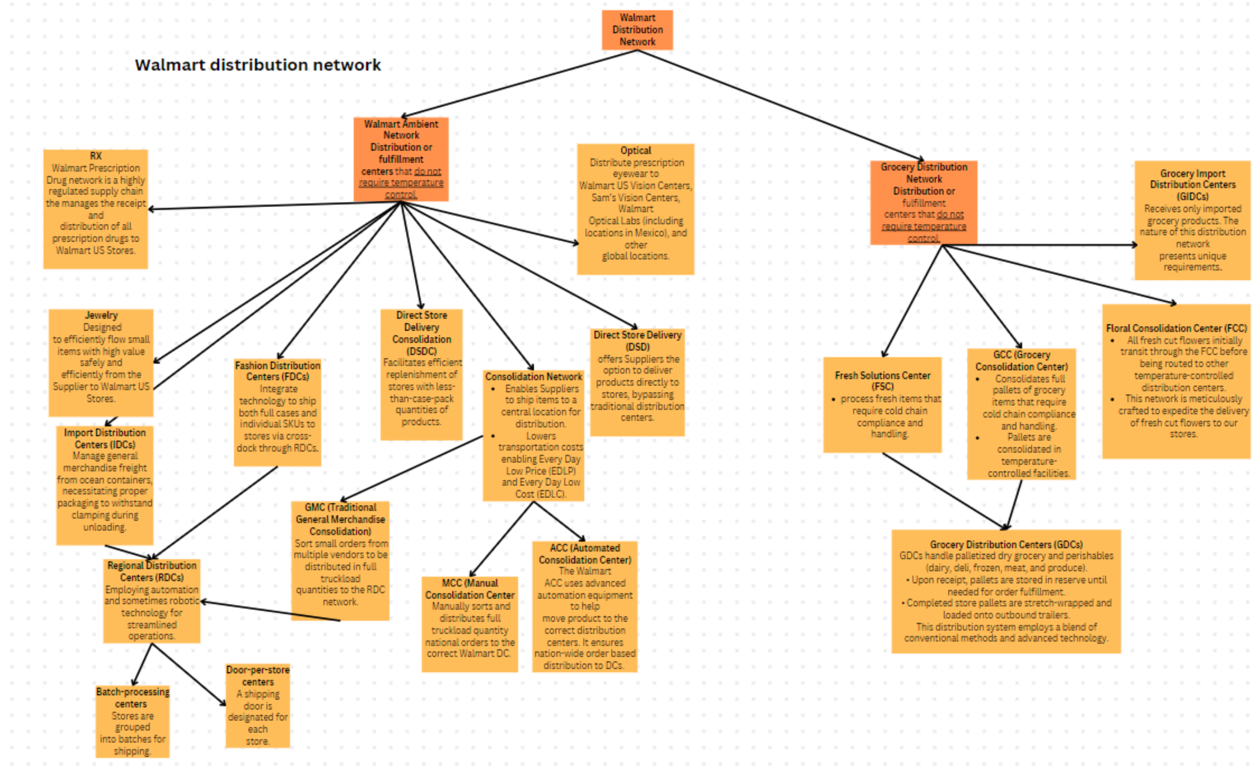

Figure 13 Walmart distribution network

3.2. Supplier onboarding process

Walmart leaves the responsibility of production management within the hands of its suppliers itself, who must periodically submit reports on their end-to-end production of their products. A similar methodology is followed when the supply wishes to sell new products via Walmart's stores as well or join its supplier base. The parties must fill out a form which accounts for all the requested information and create an account on Walmart's supplier platform which allows them to verify the production of the goods and its delivery to Walmart’s warehouses via Advanced Shipping Notice. This allows Walmart to ensure a foolproof system by ensuring a rapid inventory restock as well as store inventory management.

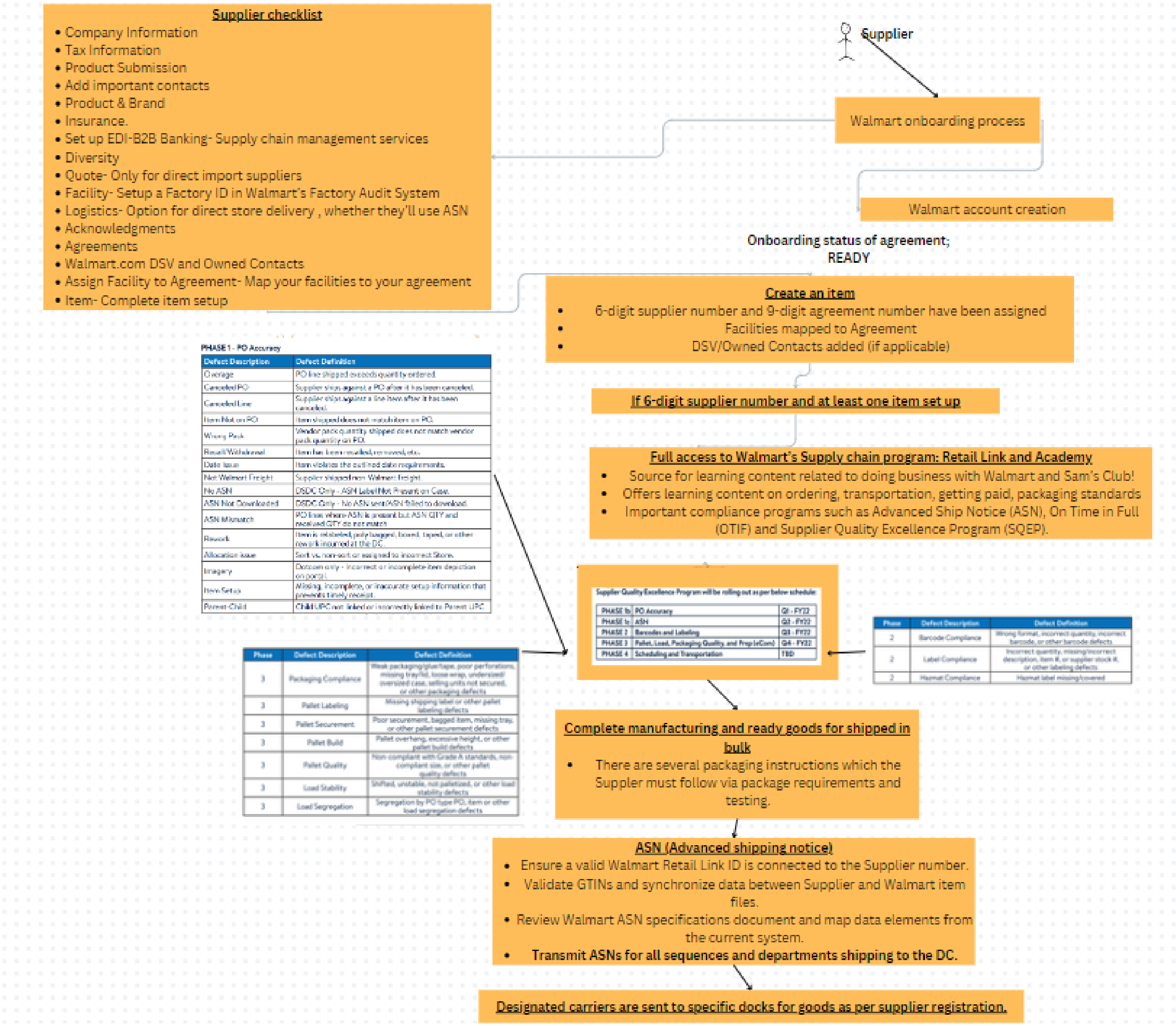

Figure 14 Walmart Supply chain joining procedure

3.3. Walmart's product authentication strategy

To ensure the authenticity of their products, Walmart has made use of security tags in the form of standard barcodes and RFIDs for all their products. The responsibility of adding these tags onto the finished product is left within the hands of the manufacturers who are provided with a instructions on where to obtain the tags from. These tags are applied on different types of products with certain packaging requirements set up to match their warehousing systems- some of which are automated. Furthermore, the brand has entered a partnership with IBM Food Trust since 2021 to ensure the authenticity of their food products. The IBM Food Trust implements AI and Blockchain technology based on Hyperledger Fabric to ensure safety and traceability of food produced from the source to the consumer. The system assists Walmart gain its customers loyalty and boosts their presence within the industry as a trusted brand.

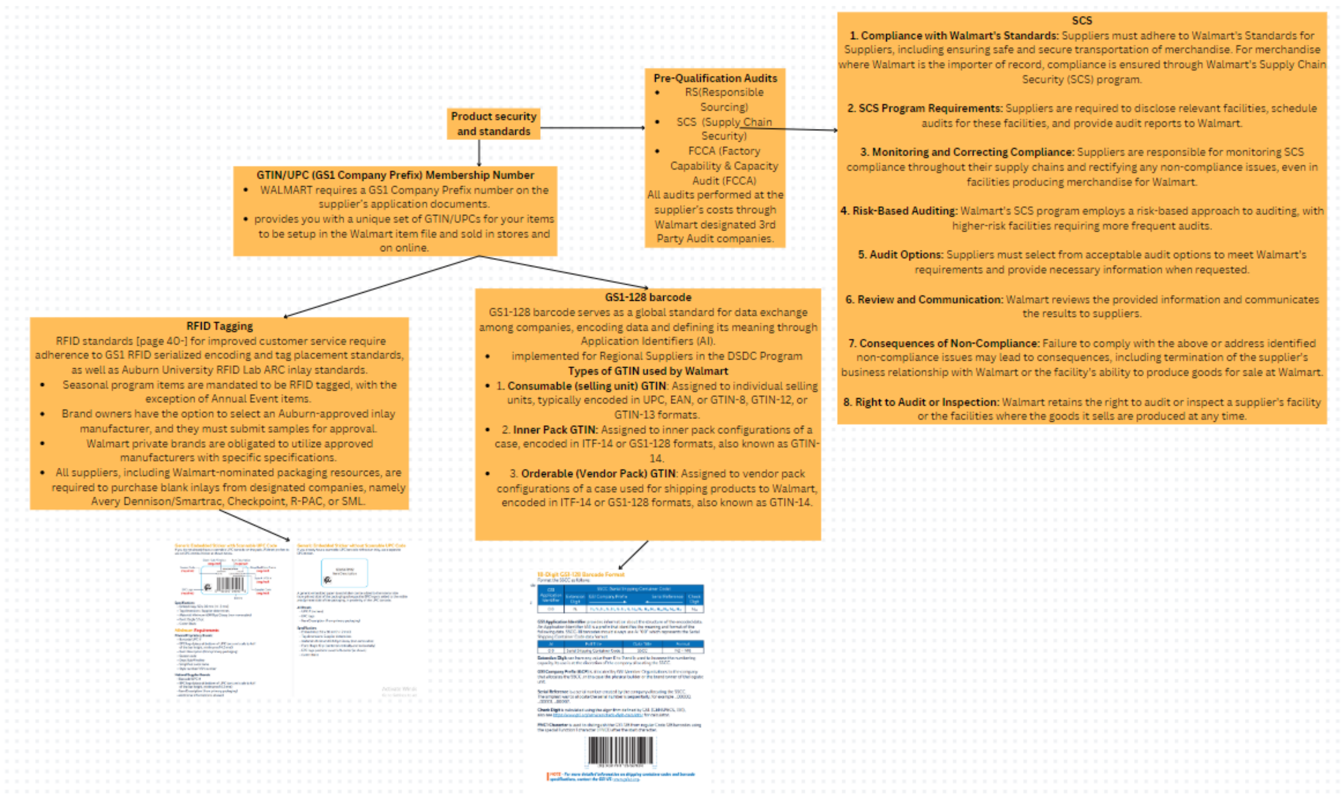

Figure 15 Walmart product security standards

Chapter -4 Computer Vision in Anti-counterfeiting technology

4.1.Role of computer vision in anti-counterfeiting

Computer vision is one of the most commonly utilized domains in the anti-counterfeiting industry. It is combined with different properties of physical objects to automate the process of detecting fake goods. Computer vision-based systems are frequently implemented in collaboration with many other technologies such as blockchain, machine learning to create robust systems that can deter individuals from identifying suspicious products. This is possible primarily due to the various features of the particular object/tag which are taken into consideration while designing the system.

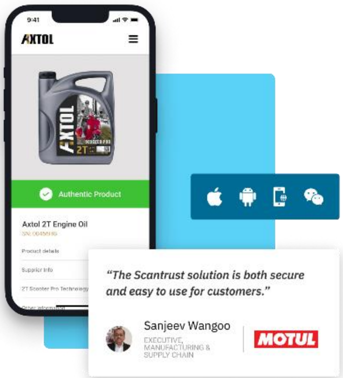

Figure 16 Scantrust mobile app

For example, a product authentication system can be designed for verification of goods by scanning a chemical based holographic tag. The scanning and authentication procedure of the tag could be performed by identification of certain unique features of the tag which stores encrypted information. By using special devices and prescribed motion for detection of the tag from a certain angle, it is possible to extract the stored information for making the required assessments and declare the product as genuine.

In the supply-chain scenario, there are several such systems that have been integrated into the supply-chain phases right from the production stage to ensure end-to-end security of the item from its manufacture to its sale at retail stores. Recent developments in such systems include the creation of mobile applications which customers can install or access via their personal devices for self-verification of the produce before purchase. For instance, the utilization of secure QR codes by ScanTrust analyzes the copy detection pattern placed within the QR code via their mobile application. It focuses on the minute squares present around the inner noise-like pattern to confirm that the QR code on the product is genuine and in turn the product itself is original.

4.2.Proposed Solution

The proposed solution for prevention of fraud within the supply chain process is the creation of a unique image-based tag which shall track the products' journey at different stages of the chain and concurrently monitoring for any form of tampering that may occur internally within the

Figure 17 Product authentication

industry. The concept involves utilizing blockchain to generate and store the tag which shall be accessible to restricted personnel and available to the customers for scanning via an application which makes use of image genuineness check via A.I models to determine a score by which the originality of the product is determined.

4.3.Factors to consider when designing

There is a plethora of factors which must be taken into consideration when designing a security tag that is to be scanned:

4.3.1 The material of the tag

The material composition of the tag is one of the crucial things to consider when initially constructing the tag. It determines the ease of scanning by the device camera. The designed tag should not contain any features which are capable of obstructing the scanning such as scratches, blemishes etc. This is ensured by using materials such as matte, gloss etc which are thick enough to avoid micro-level damages to the tag during the product’s journey to different locations.

4.3.2 Lighting manipulations

The security tag must be capable of being read under varied lighting conditions. The identifiers of the tag on the basis of which the product is authenticated must be clearly visible to the device. Many a times, tags are subjected to reflective light which obstructs the system’s light of sight and renders the scanning process to be difficult with delays. It also must be capable of scanned under darkness as well. One way to resolve this issue is to integrate low-lighting detection models, such as MirNet and Def-Net, which can readjust the lighting of the read image.

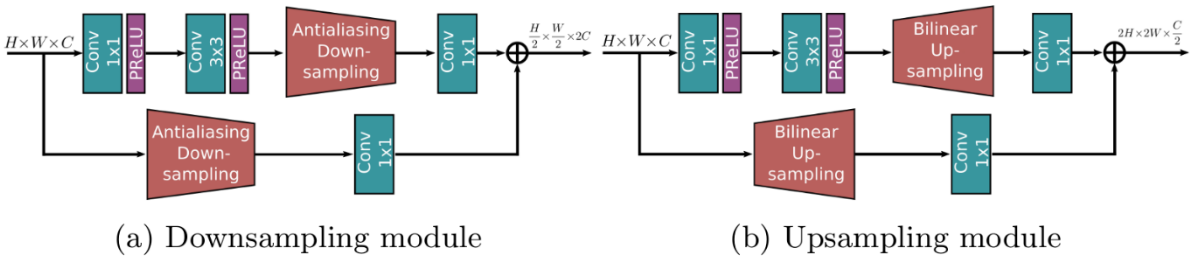

Figure 18 MirNet model architecture

4.3.3 Choosing special indicators for authentication

As there shall be thousands of distinct tags created with the same template, the created tag must contain some indicators which can be used for detecting the tag. These can be used for focusing the system’s attention to the desired characteristics to be decoded for information retrieval. The distinctiveness of the tag can be induced by using generative A.I to generate patterns that cannot be distinguished by normal human or machine perception for copying. This can help ensure that the anti-counterfeiter is incapable of recreating the tag upon scanning and reprinting.

4.3.4 Preprocessing and training models for detection

A.I-based tag verification is performed by selecting a suitable model architecture and training it on a large dataset consisting of augmented images of the tag under various lighting conditions, presence of random noise, slanted perspectives and rotated images. This is to enable the model to detect the tag from any predicted position of scanning that the user may attempt to verify from. Since there are no datasets available online which is customized to the particular task, a high-quality image dataset was created using A.I generative websites which consists of over 1000 images for small-scale testing. Additionally, training the model requires labor-intensive resources such as GPU to create an accurately performing model. For this purpose, the model was trained AWS Jupiter notebook for reducing delay in research and development.

```
#enable model architecture
const input = tf.input({shape: [784]});
const dense1 = tf.layers.dense({units: 32, activation:
'relu'}).apply(input);
const dense2 = tf.layers.dense({units: 10, activation:
'softmax'}).apply(dense1);
const model = tf.model({inputs: input, outputs: dense2});
```

Figure 19 Python model architecture code

Figure 20 Security tag dataset

4.3.5 Testing

To evaluate the performance of the model at tag detection, the tag is scanned using different devices to test the image resolution which is optimal for scanning and later decoding the image in a real-world scenario. The security tag was printed on different label materials to simulate possible image scanning situations and determine the minimum possible size at which the tag is detected by the image capturing algorithm.

Device	Image printed in tiff format on normal paper (%)	Image printed on gloss paper in tiff format (%)
Samsung Galaxy J7 prime via IP webcam	80	80
Samsung Galaxy Note 20 via IP webcam	63	75
Samsung M52 via IP webcam	80	92
Canon 77D	90	95.9

Table 1. Observations from testing security tag of size 2 inch.

4.3.6 Inferences

Scanning the security tag under different settings using different resolution cameras for scanning purposes revealed that the tag printed on gloss paper gives a better accuracy score in comparison to that printed on normal paper. The best results were obtained via scanning with a high-resolution camera of 95.9% with automatic focus enabled as shown in Table 1. On the other hand, when scanned with smartphone devices via an IP webcam app, the results varied due to the auto-focus function which was inbuilt in the device. Since M52 had the most controlled focus, the smartphone was able to achieve the highest capture and decoding rate of 92%.

Although the model achieved high accuracy during testing, the precision of capture is yet to be fine-tuned as the captured dimensions of the image tends to be altered upon preprocessing and inputted to the model. This causes distortion within the image and therefore shall require training the model on additional data to ensure that all features within the image are preserved for verification.

Chapter -5 Conclusion and Future scope

5.1.Conclusion

The supply chain industry is one of the core industries to today's present world. It involves all procedures related to the production of different products on the basis of the type of product and the audience it caters to. Hence, it comprises a wide range of complex procedures to ensure the smooth functioning of the supply chain industry. This also includes ensuring and exhibiting the genuineness of the produced product by the concerned brand as it attracts the loyalty of its customers and promotes its brand image in the retail scene.

With the elevation of counterfeiting of goods for unethical financial gains, the reputation of branded products has taken a hit. Despite the integration of security measures into the supply chain procedures and products itself, it is becoming an arduous task to identify genuine goods from fake ones. For this reason, many brands are experimenting and implementing combined technologies to ensure the uniqueness of their products through the latest available tech. Some of the emerging trends within the industry include the application of artificial intelligence, blockchain technology and cryptarithmetic methods as well. However, as counterfeiters become smarter and more equipped at cracking such advanced techniques of security, it is high time that brands look for foolproof methods of anticounterfeiting.

5.2.Future scope

For creating enhanced methods for anti-counterfeiting, it is possible to combine a plethora of the existing cryptographic technologies with other technical or engineering inventions to create a secure system that not only tracks the journey of the product but also provides incentives for both the seller and buyer. This helps establish the brand's position as a trustworthy company with authentic products that are worth the money they spend.

There is a sundry of technology for counterfeit prevention within the supply chain industry that combine computer vision approaches with machine learning to create powerful detectors of fake products. Majority of these approaches combine merge database solutions and methodological solutions derived from other fields to create systems which are capable of providing mobile and accessible services to both the retailers as well as customers.

To create a much more strict and secure system as a one-fits-all solution for the entire supply-chain industry, an A.I model is constructed using a combination of the existing approaches and models which detects authentic security tags and classifies the item as authentic or non-authentic.

The performance of the built model can be refined by adding more of relevant layers during model training or performing transfer learning and thereby utilizing existing high accurate models. This solution is a better fit for conducting research on limited data availability- which applies to the current project. An alternative approach to the problem would be to include more images for training the model which is tenuous with regards to the annotation of the dataset.

In conclusion, the integration of computer vision as a solution for counterfeiting is a highly sought after for product authentication. By applying A.I and machine learning concepts to present methods of security, these solutions can be boosted further to achieve improved and accurate remedies.

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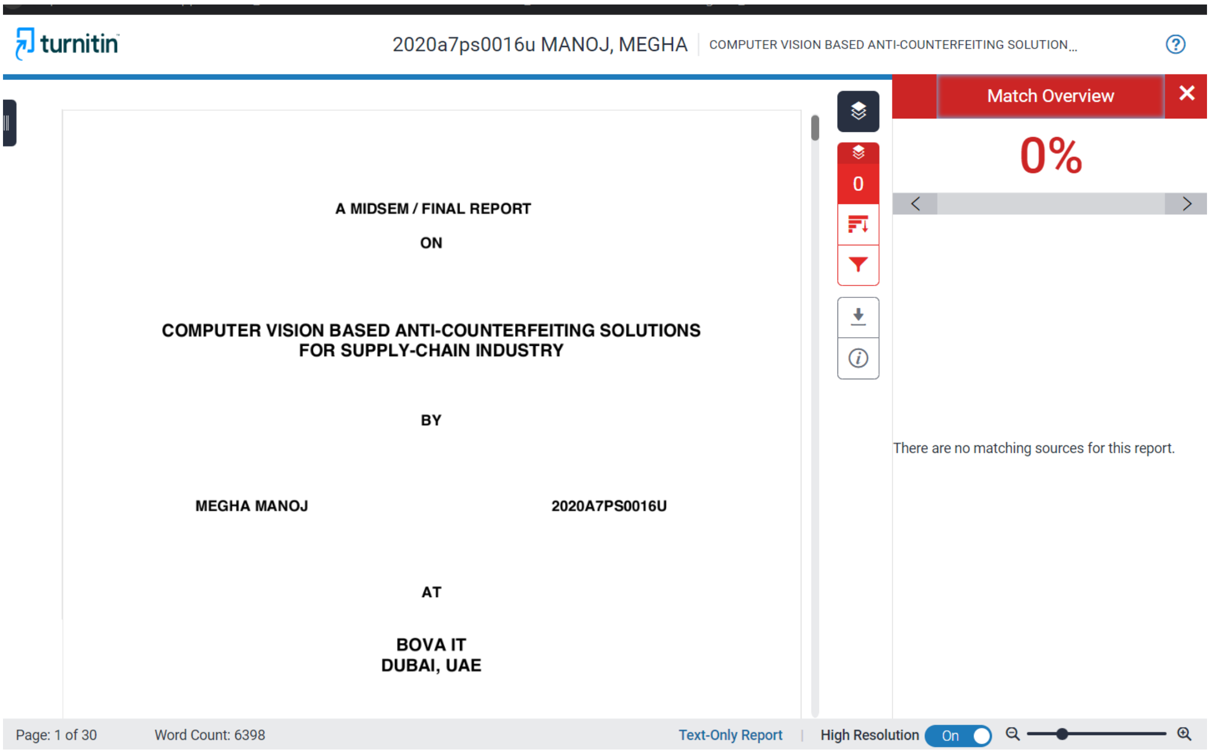
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