Enhanced Retail Loss Prevention: Leveraging a Combination of Security Cameras & Image Analysis Technology

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NEC Corporation
Executive Summary

In recent years, the retail market has continued to grow, while the challenges have also become diversified. One of the common challenges plaguing the retail industry worldwide is “shrinkage”, which is caused primarily by employee theft and external theft such as shoplifting and Organized Retail Crime (hereafter, ORC). This problem has prompted retail industry to implement various loss prevention measures such as displaying products in transparent boxes with locks, installing security cameras on the sales floor, or stationing security personnel to monitor the sales floor. However, such techniques are proving inadequate for preventing ORC and employee theft. Consequently, there is a growing need to enhance the loss prevention strategies by leveraging ICT. Especially, loss prevention techniques such as “facial recognition” and “image analysis” technologies that use security camera images are in the spotlight.

NEC continues to support loss prevention activities by leveraging its retail industry expertise accumulated through supporting retailers over the years as well as its superior facial recognition and image processing technologies.

This whitepaper discusses the current situation of retail shrinkage, conventional and ICT-driven loss prevention strategies, as well as “blacklist-based detection” and “large quantity item theft detection” solutions that leverage NEC’s proprietary technology.

1. Factors behind retail shrinkage

The continuous growth of global retail market has also seen retailers faced with a number of challenges. One of the common challenges plaguing the retail industry worldwide is “shrinkage” which continues to persist.

Shrinkage is generally considered to be made up of “employee theft”, “shoplifting”, “administrative errors” and ”vendor fraud”. Recent years have witnessed an increase in the damage caused by shoplifting (mainly in the form of ORC), and employee theft. The increase in shrinkage is an outcome of multiple factors, such as expenditure-cuts in the loss prevention measures, limitations of conventional loss prevention techniques and technologies, and the rise of e-fencing (online resale of stolen goods). Additionally, labor shortage and soaring labor costs have also made it difficult for stores to retain loss prevention personnel.

1-1. Reality of shrinkage in the global retail industry

Shrinkage is a common challenge faced by retailers worldwide. According to a 2015 survey, shrinkage amounted to 123.4 billion USD globally, and on an average, it amounts to 1.2% of the annual sales (Figure 1). The Top 6 countries in terms of highest shrinkage rates were Mexico, the Netherlands, Finland, China, Japan and Spain. United States, China and Japan were the Top 3 countries in terms of the highest shrinkage cost.

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1 LPM Insider (September 27, 2016)
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According to the same survey, the global average shrinkage rate increased from 0.9% in 2014 to 1.4%. A breakdown of shrinkage by source indicates that the share of shoplifting and employee theft in the overall shrinkage has increased from 67% to 77% (Figure 2). This amounts to an increase from the 2014 survey figures of approximately 86 billion USD to approximately 95 billion USD in the 2015 survey. These serious figures are a result of factors such as employee theft in collusion with shoplifters, sophistication of shoplifting techniques and spread of ORC.

1-2. Increase in the ORC activity

As mentioned previously, ORC is a form of shoplifting, and its increase poses a major challenge for the retail industry. For instance, in the United States, which is the largest retail market in the world, ORC is responsible for approximately 70% of the shrinkage-related damages caused by shoplifting. This is because ORC often involves large stolen quantities, leading to higher losses. Furthermore, ORC involves repeat offenders who use brazen and sophisticated methods, making it difficult for the store staff to prevent them. According to a survey, the increase in ORC-related losses has resulted in a situation where the loss prevention personnel spent 30-50% of their bandwidth specifically on ORC prevention.

1-3. Factors behind increase in shrinkage

The increase in shrinkage is a result of various factors surrounding retail industry. In particular, there are retailers who do not recognize the importance of loss prevention strategies and cut down the budget for such measures despite increasing shrinkage. Especially, the budget for loss prevention personnel such as security guards and greeters has shrunk due to soaring labor costs, thus making it difficult to retain necessary resources. For instance, in the United States, the wage increase for security guards employed by retailers tends to be higher as compared to the average wage increase for all other occupations. Moreover, in the case of Japan, labor shortage makes it difficult to further increase human monitoring.

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4 Based on a comparison of retailers participating in the 2014 and 2015 surveys
7 Global Retail Theft Barometer (2015), The Great Disconnect between LP and IT (2015)
8 Deloitte, “Retail Talent Disrupted” (2015)
9 Job Search Intelligence, “Historical Salary Data and Employment Totals by Occupation (2015)
Meanwhile, the methods of retail crimes are changing which is evident in the diversification of shoplifting techniques, rising POS frauds by employees, sweethearting, passing through the self-checkout without paying, etc. The delay in implementing strategies that can cope with such changes is also one of the reasons behind ineffective loss prevention. Furthermore, the spread of e-commerce has made it easy to resell the stolen items online, contributing to an increase in ORC. Another factor contributing to this increase is legal restrictions that do not allow the theft data to be shared among the retailers’ loss prevention departments, industry peers, police, or other relevant organizations.

The factors discussed above make it necessary for the retailers to adopt enhanced loss prevention strategies.

2. Conventional techniques for loss prevention

Over the years, various loss prevention techniques have been developed to deal with the increasing shrinkage. This section classifies the techniques into three categories based on the respective targets of these techniques, namely “items”, “shelves/sales floor” and “persons”, and then discusses their respective merits and demerits (Figure 3).

2-1. Item-centric measures

Loss prevention measures such as Electronic Article Surveillance (hereafter, EAS) systems using product tags, keeper boxes, dummy product displays using empty boxes are some of the more common measures used to protect items. These measures help in preventing shoplifting to some extent. However, use of sophisticated methods such as booster bags can evade EAS detection at entry or exit points. Furthermore, asset protection measures such as EAS that use sensors are susceptible to false alarms resulting in customer inconvenience. According to a survey, 66% of the retailers (Figure 4)\(^\text{11}\) stated that asset protection device related problems occur at least once a day. In addition to this, attaching EAS tags before shelf stacking and then removing them at the cash register adds to the operational workload of the staff. Similarly, in case of keeper boxes and dummy items, unlocking items from the keeper boxes, or exchanging dummy items with real ones have an impact on the cashier operations.

2-2. Shelf and sales floor-centric measures

Loss prevention measures such as locked shelves and security cameras are some of the

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\(^{11}\) ECR, The Impact and Control of Shrinkage at Self-Scan Checkouts (2011)
more common measures used to protect store shelves and sales floor. As in the case of keeper boxes, displaying items in locked shelves can help prevent shoplifting to some extent. However, every time a customer wishes to pick up an item for a closer look, they need to request the store staff to unlock the shelves, which significantly reduces the convenience level during shopping.

Security cameras installed on the sales floor act as a psychological deterrent towards shoplifters. Moreover, security cameras have a broader scope as they can be utilized for monitoring employee thefts in addition to detecting shoplifting. However, the current common practice is to check the camera footage after the incident, resulting in a weaker direct impact from the perspective of shoplifting prevention when compared to other methods.

2-3. Person-centric measures

Employees and greeters prove to be effective in monitoring persons engaging in any criminal activity. Human monitoring not only allows inspection of item status on the sales floor, but is also effective in detecting any suspicious individuals in the store, and in keeping track of such individuals. The staff can then take measures to prevent shoplifting, such as proactively addressing the suspicious individuals or checking their bags at entry or exit gates.

On the other hand, retailers also face the challenge of allocating dedicated manpower for loss prevention in the wake of soaring labor costs and labor shortage. Furthermore, the effectiveness of monitoring in loss prevention is person-dependent, and therefore varies. Employee education is required to maintain a certain level of effectiveness, making it a costly measure.

2-4. Limitations of conventional techniques

Although, the techniques described in previous sections are effective in preventing shoplifting to a certain extent, the reality is that they are not sufficient to deal with increasing ORC and employee theft. For instance, ORC often involves multiple shoplifters where one shoplifter diverts store staff’s attention while the other unlocks a keeper box, thereby evading any loss prevention measures. Moreover, conventional measures often fail to detect the techniques used for employee theft such as processing refunds to extract cash from POS and issuing discount coupons in collusion with shoplifters, etc.

3. Loss prevention techniques leveraging ICT and security cameras

Although, the conventional techniques are partially effective in preventing losses caused by shoplifting, these techniques are inadequate against the increasing ORC and employee theft. However, in recent years, highly improved accuracy of cameras and sophistication of analytical technologies have been instrumental in development of techniques that are effective against ORC and employee theft. Numerous techniques that combine security cameras and other loss prevention techniques, or application of image processing technology to camera images are being developed (Table 1).

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<tr>
<th>Technique</th>
<th>Overview</th>
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<td>Blacklist-based detection</td>
<td>Detects blacklisted offenders entering the store</td>
<td>Prevents ORC and crimes by repeat offenders</td>
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<tr>
<td>EAS linked with security cameras</td>
<td>Starts video recording when EAS gates trigger an alert</td>
<td>Helps in identifying the offender, and prevents repeat offences using a blacklist</td>
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<tr>
<td>Video recording linked with POS</td>
<td>Records videos at a time when there is a possibility of employee-customer collusion to commit fraud</td>
<td>Prevents fraud committed by employees on their own, or in collusion with customers such as issuing coupons dishonestly</td>
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Table 1: Examples of techniques leveraging ICT and security cameras
3-1. Techniques leveraging ICT and security cameras

Conventional techniques such as security cameras were mainly used as “after-the-fact” measure for verifying cases of shoplifting and frauds. However they can now be utilized as preemptive measures by leveraging ICT. Additionally, loss prevention measures can be made more effective by combining ICT with conventional techniques. This section describes three of such representative techniques.

The first technique is detection based on a blacklist. In case of repeat offenders or ORC, facial information of shoplifters captured on the security cameras is recorded in the blacklist; this helps in the detection of blacklisted individuals when they enter a store. Moreover, sharing such blacklist information with other stores of the same chain can effectively prevent crime throughout the chain by detecting shoplifters and taking preemptive measures against them.

The second technique involves EAS linked with security cameras using ICT. Offenders can be identified by recording the video captured by cameras at the exact time of theft detection at entry or exit gates, which can also be used as evidence of the crime. Even if the shoplifters are not apprehended after forcing their way through EAS, they can be identified with the help of security camera images. These images can be used in combination with blacklist-based detection, so that the shoplifter can be detected the next time they visit a store.

The third technique links video recording with POS. Combining security cameras with POS systems can aid in monitoring and preventing employee thefts, which has proved difficult in the past. Employee theft can be verified effectively by recording or reviewing images for a certain time window such as during the refund processing, which is often an opportunity to cheat. Moreover, it also becomes possible to prevent sweetheating where store staff colludes with a customer. Customer’s facial information is captured by the camera monitoring the POS. This facial information and the login ID of the cashier logged in at the time in question are paired and stored. Similarly in case of issuing coupons, it is possible to detect suspected employees and customers who may commit a fraud, by extracting instances that have a high number of same combinations of cashier information and customer’s facial information.

3-2. Leveraging AI technology

Utilization of ICT and security cameras can aid in implementing measures against ORC and employee theft, which was difficult in the past. As discussed in the previous section, combining security cameras with image processing technology can prove effective against ORC and employee theft. Moreover, loss prevention techniques are expected to be enhanced even further as these techniques leverage not only image processing technology but also Artificial Intelligence (AI).

For instance, AI can be used to analyze behavior, facial expressions and eye movements of the person captured on the camera and then these features can be cross-referenced with patterns of suspicious behavior or expressions, leading to the detection of a suspicious individual. Furthermore, other fraud or crime detection techniques under consideration involve data linking where images can be used to analyze in-store movement and then linked with other data such as dwell times, shopping data, facial information, etc. to detect any criminal activities.

Thus, leveraging camera images and AI technology is expected to enhance the loss prevention techniques even further.
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4. Loss prevention initiatives leveraging NEC’s technology

NEC has world’s No.1 image processing technology, and has introduced solutions leveraging this technology in various domains. NEC’s cutting-edge image processing technology continues to evolve through continuous R&D, and can be used for retail loss prevention measures by contributing towards strategies against shoplifting, ORC and employee theft.

4-1. Blacklist-based detection

Utilizing ICT with security cameras can enhance loss prevention measures, however, leveraging image processing technology in retail store environment requires superior technical expertise. For instance, the facial recognition technology used for blacklist-based detection requires the captured facial images to be “front-sided” and “clear” for a high-accuracy recognition. However, the security cameras in stores are installed near the ceiling, and the customers move around the store freely without being conscious of the security cameras, making it an unfavorable environment for capturing facial images for facial recognition. Therefore, highly accurate and correct recognition of individuals becomes a challenging requirement for leveraging facial recognition technology in the retail environment.

NEC’s facial recognition technology has continued to evolve through continuous R&D aimed at offering "world's most accurate, high-speed facial recognition algorithm". In recent years, Deep Learning was adopted in facial recognition technology; this has enhanced the robustness of technology in situations such as constantly changing face direction, overlapping physical profiles of individuals, temporarily or partially hidden faces, low resolution facial images captured from a distance, etc. This capability has helped NEC achieve top ranking four consecutive times for its performance in the facial recognition benchmark evaluation sponsored by National Institute of Standards and Technology (hereafter, NIST). Another fact that deserves special mention is that NEC was the only entity to achieve more than 99% recognition accuracy in the 2017 NIST benchmark test which involved a real-life environment requiring to identify moving faces while walking naturally without minding a camera or without stopping in front of a camera. Moreover, NEC achieved the lowest error rate when tested for important factors affecting surveillance such as small facial images and changes in the face direction. On comparison, NEC’s error rate was half of that of the competitor placed second.

Thus, NEC’s facial recognition technology enables high-accuracy recognition even in store environments, and can be leveraged successfully in the blacklist-based detection, and identification of persons based on POS and EAS linking. This can enhance loss prevention

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12 Deep Learning : AI and Machine Learning technology that uses multilayered neural network

13 http://jpn.nec.com/press/201703/20170316_01.html
measures against ORC and employee theft.

Moreover, NEC leveraged its high-accuracy facial recognition technology to develop a “Profiling across Spatio-Temporal Data” technology 14; this technology can rapidly classify and search individuals appearing in a specific pattern based on time, place and behavior criteria from the video data covering long time frames and multiple locations. This technology is an algorithm that creates groups based on “similarity” in faces from a large amount of video data, enabling detection of subjects matching specific appearance patterns. This technology makes it possible to search a person by appearance time, location, and appearance frequency by grouping the appearance patterns of a person considered to be the same person based on facial similarity.

For instance, loss prevention techniques can be further improved throughout the store chain by detecting “a suspicious person appearing frequently in the same store” or “a suspicious person appearing in multiple stores” from the security camera images.

4-2. Shelf monitoring to detect large quantity item theft

In addition to the facial recognition technology, NEC has also developed a technology that can detect object movement using image processing. This technology can be leveraged for detecting abnormal situations when monitoring shelf items using cameras. Specifically, any unusual movement of items displayed on the store shelves will be captured by NEC’s proprietary ‘difference detection’ technology through an analysis of the security camera images. This technology will judge a situation as abnormal if large quantities of items are removed suddenly, and trigger an alert. Conventional item-centric asset protection techniques used against shoplifting, such as item tags led to an increase in the operational workload of employees. However, by leveraging this technology, employees will not be required to respond every time as the abnormal conditions will be detected through security camera images. Furthermore, it is especially effective against ORC which usually involves thefts in large quantities.

NEC’s ‘difference detection’ technology has been developed by leveraging the expertise accumulated through NEC’s support of retailers over many years, and thus has the capability to achieve detection successfully even in a store environment. For instance, there is constant movement of customers and employees in front of store shelves. Moreover, there are cases where customers tend to dwell longer in front of shelves with cosmetics as they try out samples, or shopping carts are left unattended. In such a challenging store environment with various possibilities, it is necessary to have a mechanism that can correctly detect only the relevant events, and limit the occurrence of false detections to the best extent possible.

Specifically, NEC’s ‘difference detection’ technology can detect movement of items by excluding the human movement of customers and employees when analyzing the security camera images. At the same time, the

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14 http://jpn.nec.com/press/201511/20151111_02.html
technology enables retailers to set up the scope target area for detection easily and intuitively as well as the threshold for triggering the alert. Thus, even in case of retail environment where store layouts and product range change fast, it is possible to have a successful large quantity item theft detection system that can be configured and operated by any member of the store staff without undue operational stress.

5. Conclusion

The conventional loss prevention techniques have various limitations, and are particularly inadequate against employee theft and ORC. Latest ICT must be leveraged for developing effective techniques to deal with these problems. Combining ICT such as image processing or facial recognition technologies with security cameras makes it possible to respond effectively to such problems and enhances the overall loss prevention strategy.

As a leading technology company, NEC possesses world-class proprietary technologies. Furthermore, NEC has an extensive expertise accumulated over many years by supporting retailers worldwide, including Japan. A combination of these technologies and retail expertise can enhance loss prevention techniques such as “large quantity item theft detection” for shelf monitoring, and “blacklist-based detection”. These can contribute to strategies against ORC, and at the same time can also be leveraged for detecting thefts by store employees, thereby, contributing to loss prevention.

NEC will continue its technological R&D, and will continue to contribute towards further enhancing retail loss prevention.

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Authors
Name: Narumitsu Notomi
Organization: NEC Corporation
Title/Affiliation: Senior Manager,
Business Strategy & Marketing Group, 1st Retail Solutions Division
Area of Expertise: Business Strategy, IT Strategy, Retail IT

Name: Masaaki Kimura
Organization: NEC Corporation
Title/Affiliation: Assistant Manager,
Business Strategy & Marketing Group, 1st Retail Solutions Division
Area of Expertise: Business Strategy, IT Strategy, Retail IT

Name: Yuko Mayuzumi
Organization: NEC Corporation
Title/Affiliation: Assistant Manager,
Business Strategy & Marketing Group, 1st Retail Solutions Division
Area of Expertise: Global Retail Market Research

Name: Masamichi Tanabe
Organization: NEC Corporation
Title/Affiliation: Senior Manager,
Business Strategy & Marketing Group, 1st Retail Solutions Division
Area of Expertise: Retail IT, Image Solutions

Name: Junpei Yamasaki
Organization: NEC Corporation
Title/Affiliation: Manager,
Business Strategy & Marketing Group, 1st Retail Solutions Division
Area of Expertise: Retail IT, Image Solutions

Name: Takayuki Nakagawa
Organization: NEC Corporation
Title/Affiliation: Assistant Manager,
Business Strategy & Marketing Group, 1st Retail Solutions Division
Area of Expertise: Retail IT, Image Solutions

Name: Nikhil Ranade
Organization: NEC Technologies India Private Limited
Area of Expertise: Global Retail Market Research, Branding

Company Overview
Company Name: NEC Corporation
Head Office: 7-1, Shiba 5-chome Minato-ku,
Tokyo 108-8001, Japan

Business Overview:
NEC has been a leader in the field of industrial technology, and we have been a driving force behind the development of cutting-edge technologies in the three areas of computing, network, and software solutions. We have been also promoting various research and development initiatives that look into the future in the advanced areas of data science and artificial intelligence (AI). As a ‘Value Provider’ we are focused on the values of “Safety,” “Security,” “Efficiency,” and “Equality” through our Solutions for Society business, as we work to solve social issues from a global angle with the ultimate goal of helping people live more prosperous lives.

Brand message:
“Orchestrating a brighter world”
NEC brings together and integrates technology and expertise to create the ICT-enabled society of tomorrow. We collaborate closely with partners and customers around the world, orchestrating each project to ensure all its parts are fine-tuned to local needs. Every day, our innovative solutions for society contribute to greater safety, security, efficiency and equality, and enable people to live brighter lives.