Geospatial information linkage of five senses

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Key words: Five senses, Geospatial information, link, tagging

SUMMARY

Today, people communicate more often thanks to the advancement of telecommunication devices and the Internet. One of the most frequent topics of communication would be locations, which can be identified by a form of question – 'where are you?'. The answer would be easily informed by address information and/or adjacent landmarks, such as houses, firms, markets, cafes, etc. However, informing location based information would be difficult for some people in criminal situations. These people may be troubled by lacking cognitive ability or poor judgement due to extreme stresses; they may express their locations sensed by instincts – these include sight, hearing, smell, touch and taste. The objective of this study is to promptly identify locations in questions by connecting existing address data and a few keywords informed by five senses of the criminal situations.

The study is intended to assist the police more quickly identify the locations in questions and settle the criminal situations scenes as soon as practical. The output datasets from this study would be additional attributes to the existing spatial information where the additional attributes can be filled with the keywords learned by the five senses. These keywords can be collected by field visits, web-portal base roadview images and Mobile Mapping Systems (MMS), and be reproduced into more granular information proper to the existing spatial information. The outputs can smartly serve the police phone tracking to identify locations in questions by filtering the keywords within the error range, and therefore the police can minimize locating times and arrive at the locations as soon as practical.

It is expected that this study will be of great help in police security management by minimizing the time to locate reporters in criminal situations.

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1. We live in a crime city.

What people who visit Korea for a specific purpose commonly evaluate and are satisfied with after visiting is the security situation. It provides a very high level of security than any other city in the world. No matter which city you visit in Korea, you can experience a high level of security. It is not dangerous to jog early in the morning or walk alone on the streets late at night. There may be various reasons, but first of all, Koreans have a very high level of awareness about law-abiding. In addition, CCTVs installed in various parts of the city record you and your surroundings 24 hours a day. And the police station, which is deployed in a high density distribution, is also an element that keeps you safe. For these various reasons, many people who have visited Korea return thinking that Korea is a very safe country. Then, is Korea really a perfect state from security and crime?

  If you check the crime statistics of the National Police Agency, which is in charge of security in Korea, the average number of major crimes that feel life-threatening is 500,000 over the past five years. And among them, homicides that take lives account for 0.001% of the total number. It may seem weak in terms of numbers, but in the case of a brutal murder case, it leaves great trauma and fear not only to the victim, but also to the related family and acquaintances, as well as to everyone.

It is also necessary to look at the conditions of the police. The number of cases reported to the police operation command center has reached an average of 19 million per year over the past five years. These numerous requests must be encountered and responded to daily. The information received is the responsibility of the police officer who receives the call. It is necessary to track the location by instantly analyzing and judging numerous natural languages. However, it is very difficult to link the system or related spatial information that can support this process of the police.

There is no country in the world completely free from crime. It can be relatively safe, but it can never be perfect.

1.1 Crime City threatens our safety.

NUMBEO, a global country/city comparison statistics site, announces the crime index (safety index) by country. The crime index is an estimate of the overall level of crime in a particular city or country, and the safety index is a value calculated inversely. As of 2021, South Korea was ranked 115th in the crime index (21st in the safety index) among 135 countries, belonging to a country that is safe from crime.

It is practically impossible to compare the level of security uniformly in each country. Because the definition of crime differs from country to country, and the awareness rate of crime is also different. Unlike the Korean standard, the international murder rate does not

include attempted murder and conspiracy to commit murder. Korea's homicide rate based on this standard is 0.60 per 100,000 population as of 2020, which is internationally low. However, it is more than twice as high as Japan (0.25 cases), which has a similar economic level, cultural background, and region.

According to the 2020 police statistics published by the National Police Agency, the number of total crimes nationwide over the past five years (2016-2020) has maintained an average of 1.6 million per year. Although the number of major crimes such as murder, robbery, rape, arson, theft, and violence is steadily decreasing, crimes that threaten the lives of the people continue to occur, with an average of about two murders and attempted murders occurring every day.
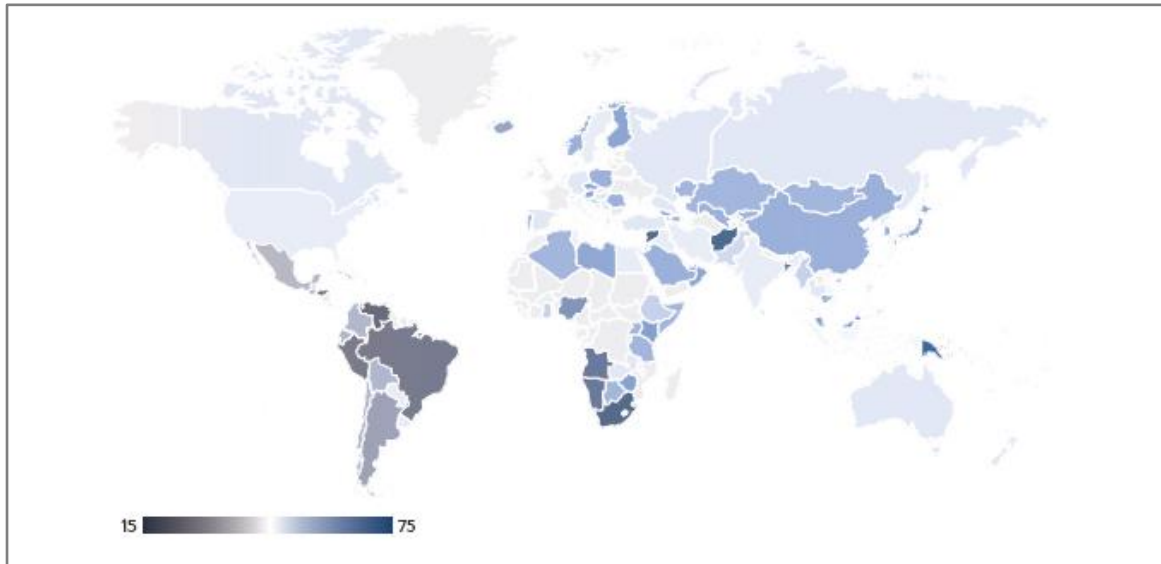

Figure 1 Crime Index by Country (2021) / Source: NUMBEO

I will cite a specific incident that occurred in Korea as an example. A woman in her 50s called the police operation command center saying that someone was holding a knife and trying to kill me. About 20 police officers were dispatched to the location confirmed by the receptionist through cell phone location inquiry, but they wandered around for several tens of minutes because they could not find the exact location. Eventually, the police found the location of the crime and arrested the culprit 50 minutes after receiving the report, but the victim had already died after being stabbed several times.

In another incident, a woman in her 30s, who was subject to personal protection for dating violence, confronted her ex-lover, the abuser, and sent an emergency rescue signal to the police by pressing her smartwatch twice. When the police arrived on the scene 12 minutes after the first report, the complainant was already bleeding and was taken to the hospital, but died. The police explained that at the time of the first report, the location information of the smart watch was judged to be another place about 500 meters away from the reporter's house, so the dispatch was delayed. Since the police arrived at the location within 3 minutes of the first report, it was an incident that could have saved the life of the reporter if they had been

able to determine the exact location of the victim.

There may be various reasons for this unfortunate incident, but the most important fact among them is that there is a gap in both situations. There is a gap between the situation felt by the reporter or witness and the police officer listening to the story. The on-site situation conveyed through wired communication is not conveyed through video. I have a basic response manual related to emergency situations, but I can't know every element of a trivial but important situation that I'm calling. The complainant will continue to speak out asking for help. The reporter is in a serious stressful situation and is conveying all of the situation through intuitive expressions such as being seen or heard. They rely only on their short-term memory to communicate their location. Police officers should ask key questions to understand the complainant's situation. This is because even small clues can play a decisive role in location tracking. Only the keywords that the reporter says are clues, and the cell phone's location tracking technology helps, but there is still a large margin of error.
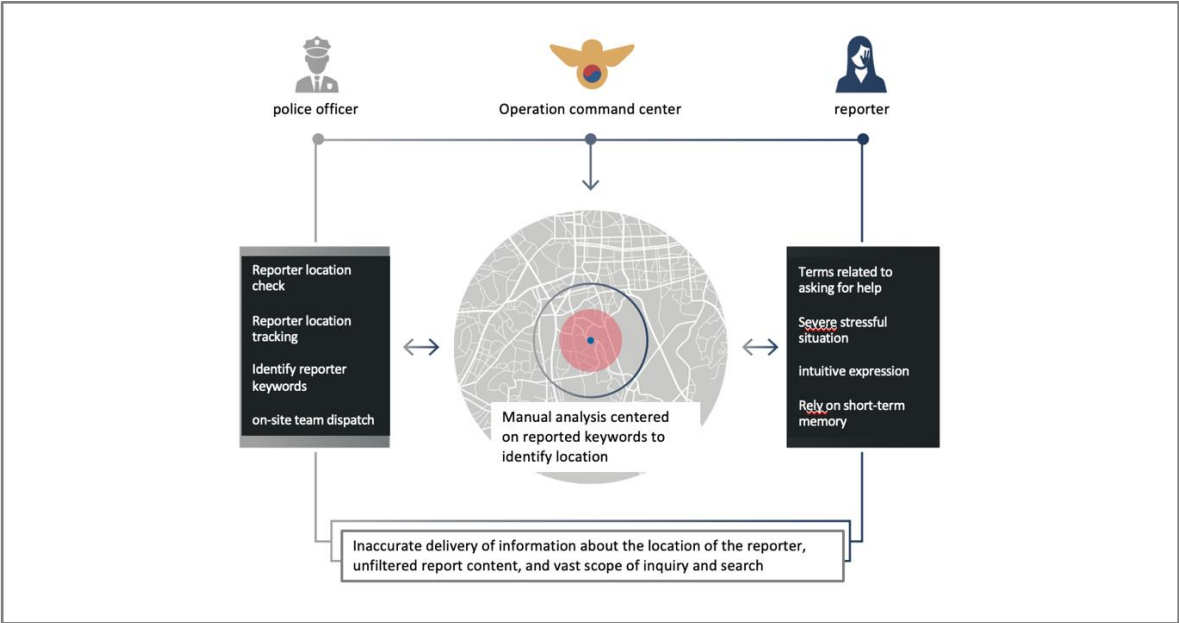

Figure 2 Situational gap

1.2 How are you doing location tracking?

In the case of Korea, the response to reports by the police is largely classified into five categories from level 0 to level 5. In order to prevent cases where emergency reports cannot be responded to in time due to non-urgent 112 reports, the dispatch system has been improved so that non-urgent reports are dispatched after emergency reports are processed. Among them, 'Code 0', along with 'Code 1', is the highest level of emergency among police work manuals issued when kidnapping, confinement, murder, robbery, etc. are suspected. In the middle of a

phone call with the reporter, it is immediately transmitted to the police station in an urgent situation that requires a dispatch order, and work support such as dispatch to the site is provided. About 18 million 112 calls were received last year alone. Of these, about 2.5 million cases, or 14%, were classified as "Code 0" and "Code 1" requiring emergency dispatch. An average of 5 112 calls per minute per day across the country were identified as emergency situations classified as "Code 0" and "Code 1".

It is fortunate if the reporter accurately knows his/her location and correctly communicates it to the receptionist, but the situation frequently occurs when a reporter in a crime, disaster, or disaster does not know his or her location or cannot properly tell it. At this time, the positioning system is activated. It is to identify the location information of the reporter by using the location-based service (LBS).

(Cell) method, satellite signal (GPS) method, Wi-Fi method, and mixed positioning method. In other words, the legal basis for using personal location information for emergency rescue is well established. According to Article 29 of the Act on the Protection and Use of Location Information, emergency rescue organizations such as police and fire departments can receive location information from telecommunications companies and use it for emergency rescue activities.

Location information is not automatically provided to the police situation room, but requires a separate request from the mobile operator. When the police request the reporter's location information from the telecommunications company, the telecommunications company first provides the location information of the base station, and secondly provides the location information of the reporter by receiving the GPS or Wi-Fi signal of the mobile phone. However, there may be an error between the location information received from the mobile communication service provider and the actual location of the reporter. The accuracy of the location information varies depending on the method by which the mobile carrier identifies the reporter's location information and the characteristics of the reporting area, and there are shadow areas where location confirmation is impossible.

Code	contents
Code 0	In Code 1, mobile crimes, violent crimes, current laws, etc.
Code 1	Imminent, ongoing, or imminent danger to life or body
Code 2	If there is potential danger to life or body, or if crime prevention is required
Code 3	Immediate on-site action is unnecessary, but investigation, professional consultation, etc. are necessary
Code 4	Non-urgency civil complaints and consultation reports

Table **1** Emergency dispatch code classification
(Source: The board of audit and inspection of KOREA)

1.3 More geolocation information is needed

In Korea, the results of the 2021 emergency rescue location information quality measurement were announced. above the emergency
The quality of measurement information is determined by how quickly and accurately location information is provided by temporarily turning on the function of the terminal in case of an emergency when the positioning technology (base station, GPS, Wi-Fi) function of the three mobile communication companies and other terminals is 'off' and poor. is to measure
The Korea Communications Commission discloses these results every year to encourage improvement in the quality of emergency rescue location information from the three mobile communication companies.

Method	Advantages	Disadvantage
Cell method	· Available on all mobile phones · Can be measured indoors or underground	· Impossible to determine exact location (200m-2km)
GPS method	· Relatively accurate positioning possible (10-30m)	· Unable to check location inside the building, underground, etc.
WI-FI method	· Location can be checked even in the basement or inside a building · It is inferior to the GPS method, but relatively accurate location confirmation(30-50m)	· Difficult to locate in areas without a wireless Internet router

Table 2 Comparison of pros and cons of each location tracking method
(Source: The board of audit and inspection of KOREA)

According to the 2021 results, the average error was 146.3 m for base stations, 53.8 m for GPS, and 56.1 m for Wi-Fi. The location success rate, which is the rate of reception with an error of less than 50 m and a response time of less than 30 seconds, was 86.5% for GPS and 86.6% for Wi-Fi. Compared to the previous 2020 results, overall improvements in positioning accuracy and positioning success rate were achieved.
However, the actual error may be greater than this. Quality measurement tests are centered on urban areas, so accuracy may be lower in suburban or mountainous areas. In the case of a base station, in practice, an error of up to 2 km may occur. Also, the problem is worse if you are indoors or underground. Since satellite signals cannot be received, accurate GPS location information cannot be obtained.
When there are many buildings or facilities in the vicinity, location identification becomes more difficult. Most criminal situations will be located out of sight of the surroundings. To put it simply, there are many cases that will happen inside a building, but it will be quite difficult to transmit location information using GPS indoors due to technical limitations where there are many GPS reception failures even outdoors with many buildings.
The location information that can be provided also varies depending on the device used by the reporter. According to the Korea Communications Commission, terminals from major foreign

manufacturers do not provide precise GPS or Wi-Fi location information, or only provide limited information. iPhone provides GPS location information only during an emergency call, and Wi-Fi does not provide location information because the positioning module of the three mobile communication companies is not installed. In the case of Xiaomi and Huawei, it was found that both GPS and Wi-Fi are not equipped with positioning modules from the three mobile communication companies. Therefore, in the case of specific smartphones, most of the cases do not provide GPS and Wi-Fi positioning, except for base stations with large error in position information, so it is difficult to accurately position during emergency rescue.

In the first case mentioned above, the GPS of the reporter's mobile phone was turned off, so the police officer in the situation room identified the location of the location with information obtained through the location of the base station and Wi-Fi. Since the error range of the location inquiry using the base station and Wi-Fi is about 50 to 100 m, in this case, there were about 660 households in the range. In the second case, confusion arose when the police were dispatched to a completely different place after receiving only the location information of the base station from the smart watch at the time of the first report. As such, there are limitations in determining the exact location of the reporter only with the location tracking system and location positioning technology. For this reason, the operation command center encourages the reporter to provide specific and accurate location information as much as possible. Even if this fails, even a single clue like a thread that can determine the location of the reporter must be pulled out and used.

There are so many different ways to announce where you are in normal situations. You can use your smartphone to check your location and inform you, or you can use the name or place name of a nearby building to inform you. However, this is only possible under universal and ordinary circumstances. You cannot do that in an emergency situation where you are exposed to crime. Reporters or victims must inform their location with minimal actions or measures. Since everyone contacted to inform of the danger and ask for help, everyone would have used their cell phone, and the only way to notify their location through radio waves or signals from the cell phone would be difficult due to technical limitations.

Method	Success rate(%)	Positional accuracy(m)	Position response time (sec)
GPS	86.5	53.8	11.4
Wi-Fi	86.6	56.1	7.5
Cell	–	146.3	4.9

Table 2 Emergency rescue location information quality measurement result by method
(Source: 2021, Korea Communications Commission.)

2. Visualization of spatial information of five senses

Various situations were listed, such as the statistical figures of the crimes listed above, people in criminal situations, the coping system of the police to deal with them, and the method of tracking the location. So, what do each of these situational factors have in common?

The goal of this study is to link the five sensory information with the existing spatial information and to search for location information with the keywords of the five sensory information in the basic map.

If people in a criminal situation deliver the maximum amount of information that can be conveyed and that information plays an important role, it will be a key element that is essential for the police's rapid response.
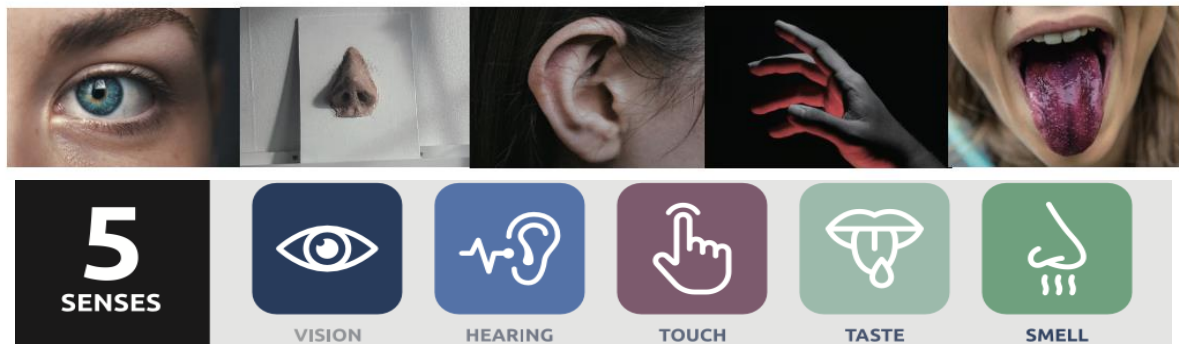

Figure 3 Five senses (Source: Unsplash)

2.1 Concept and Necessity of Five Sensory Information

2.1.1 What are the five senses?

Five senses refers to the five senses of sight, hearing, smell, taste, and touch and classified according to body organ. Everything that exists in life is related to the five human senses, and often refers to or affects the five senses.

A beautiful building, a church bell with a good sound, a rib house with a delicious smell, a salty beach, a shower room, a fence with a sharp touch, etc. Existing in the physical environment is defined or expressed as expressions based on the five senses. In order for a fact to have the form of information, the fact of the target must be able to be delivered in the form of knowledge, such as a specific type or data. herefore, in order for the contents related to the five senses to have the form of complete information, the forms of several similarly expressed natural languages must be expressed in one standardized form, and the form of combining with other information that can be linked to the five senses is not used alone. It will be reasonable.

In other words, the complete five-sensory information is to first classify similar expressions expressed by the five senses in daily life into the senses of each receiving organ, and to link them with administrative information possessed by objects expressing the five senses in a standardized form.

2.1.2 Necessity of Five Sensory Information

Why is sensory information necessary? Human beings are inseparable from the concept of place. Sleeping and waking up, going to school or work, enjoying leisure time, and coming back home all these actions can be expressed as "Where are you?" The concept of 'where' has basic administrative information (lot number, address, trade name, type of business, etc.). However, the place called may be a familiar place, a place you go to for the first time, or a place you are forced to go to.

Places to familiar places can be expressed as basic administrative information. The first place to go with a purpose is poor, but it can be expressed as the minimum administrative information that can convey information. However, since there is no basic right or motivating purpose in the place where they are forced to go, it will be difficult to express it with minimal administrative information. How about expressing it using the five senses?

Of course, it is possible to express the five senses by mobilizing adjectives of various expressions for familiar places such as residences, living areas, and workplaces. It is possible to express through the five senses, such as a house with a blue gate, a third floor of a red brick building, a shopping mall that smells of sesame oil, and a workplace where you can hear the sound of noisy machines and cars passing by. Then, is it possible to express the first place you go to regardless of your will? It is also possible. It is not a familiar place, but it is possible to express through the body organs that are proud of the five senses.

In this way, the concept of a place expressed through the five senses does not differ greatly in the content of information whether it is a familiar place or an unfamiliar place, only a difference in the degree of detail. The problem is not the presence or absence of expressiveness. Information about a place can be expressed through the five senses, but since it does not exist in the form of five sense information, a big problem can arise in delivery. Therefore, it is absolutely necessary to provide information in a form that can be guessed and confirmed to some extent by processing it into information form and linking it with relevant existing place information.

2.1.3 Add information to the five senses

In order to construct representations of places in general society as administrative information, it is divided into classifications of various attributes.

In order to construct representations of places in general society as administrative information, it is divided into classifications of various attributes. And adding the necessary five-sensory information to it does not mean ignoring all administrative information representing the existing place and building new information. It adds to the information that already exists. It is to add expressive information expressed through the senses expressed through various physical organs of human beings to universal administrative information expressing places. This will be very important information that can guess the location even in a situation where the information of the five senses is essential and expresses one's location and place by instinct where administrative information is not expressed. Every place started from the most primitive and instinctive expression expressed through human senses, not made

with administrative information from the beginning. And that expression is still the core information we use when expressing information about the place in a new place where there is no prior information at all. It is very important to turn this information into administrative information and add it to the information of existing places.
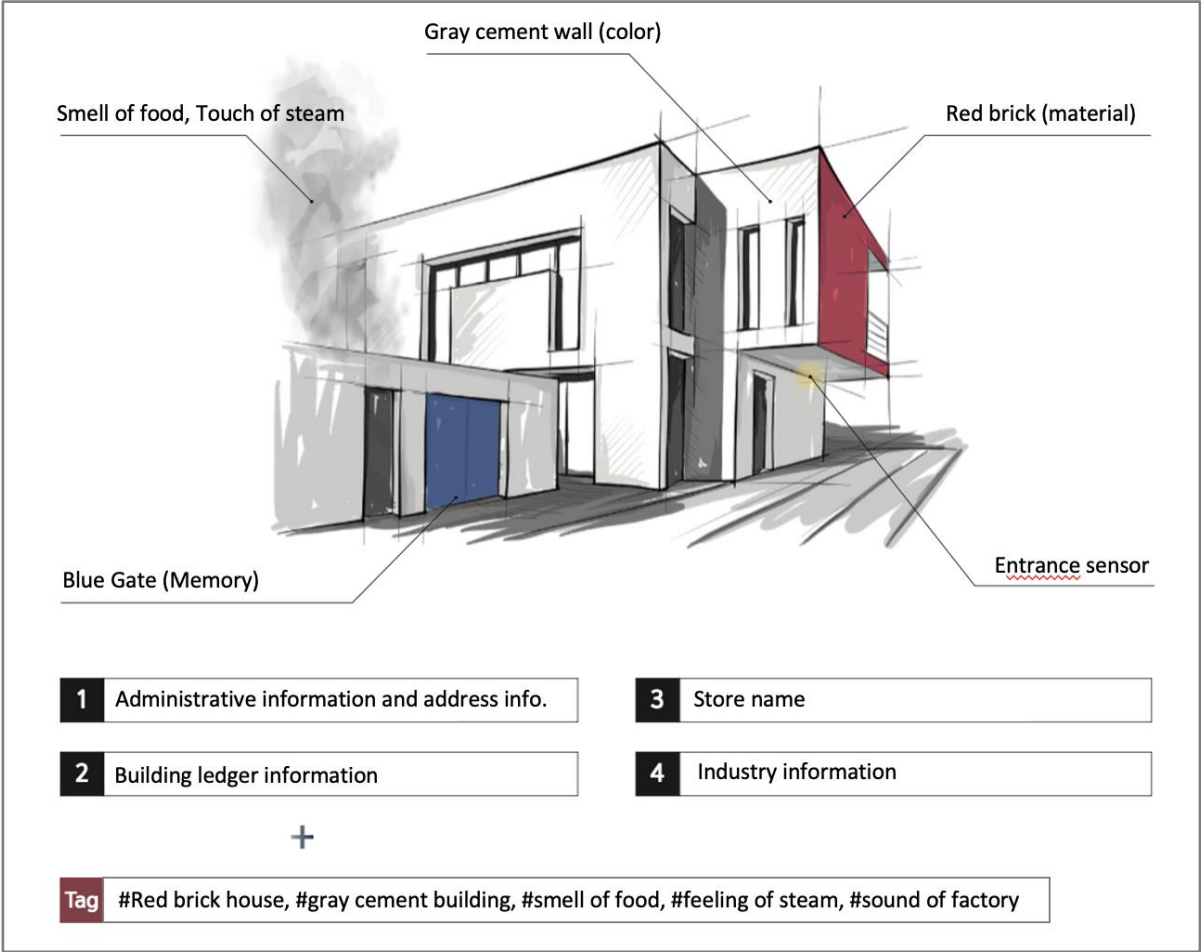

Figure 4 Existing place information + Five senses information

2.1.4 <u>Necessity of Victims' Five Sensory Information in Crime Situation</u>

Stress is a psychological phenomenon that is unavoidably experienced in the process of adaptation, and there are various ways humans cope with various stressful situations. Among them, the ability to express oneself is the ability to convey information in words appropriate to the purpose and situation, but it works abnormally when placed in a stressful situation. Subjects exposed to violent crimes are put in extreme situations where they feel life-threatening, and their cognitive abilities and communication abilities do not work normally.

Not all situations are reportable, but when reporting is possible, the key factors that the police situation room will ask are: first, the situation you are in, and second, where you are reporting. Accurate delivery of the two key elements plays a very important role in determining the success of the police's initial response. However, extreme stress causes impairment in communication ability, and the fact that it is felt through the senses through the body organs, that is, through the five senses, is conveyed by relying on short-term memory due to psychological pressure and fear. The things you see right in front of your eyes, the sounds you hear, the feelings you touch, and the smells...

Keywords related to the five senses delivered in this way should be delivered to the police officer who has been requested for assistance in the form of information linked to the existing location information. If it is a 'red house', it must be delivered in the form of information combined with previously established administrative information such as lot number, road name address, type of business, building or place name of an actual building with red color within the error range through phone location tracking. You can guess the place. Informatization of the five senses is a very important factor in identifying the location of a person who actually needs help, and a single word expression can have the most decisive effect in confirming the location.

Figure 5 Stress situation (Source: Unsplash)

2.2 Linkage mapping between five senses info. and existing spatial info.

2.2.1   Linkage with existing spatial information

As described above, in order for the expression of a place acquired through the five senses to have the form of information, it must be linked with the basic spatial information of the place. Basic spatial information includes various types of spatial information, such as parcel information, road name address information, classification of relevant places, PNU of building ledger information in case of buildings, use classification, area information, and floor information. Among them, PNU information, which is the information that all places have the same, is information recorded with a total of 19 digits as a unique lot number. This 19-digit number contains administrative district information and parcel lot number information.

This means that all places have this lot number, whether a specific place is an open area without a building or a place with a building. Therefore, it is possible to additionally attach five sensory information that is newly investigated and informatized based on the unique number of the lot. The newly constructed five sense information is not used alone, but can be used in the form of proper information as it is linked with existing place information.

2.2.2 Mapping

When information on the five senses is collected through various collection methods, it goes through the process of linking it with existing spatial information as described above. It is not to change the DB structure itself related to the original place, but to use matching or tagging to additionally link the five sensory information. Once this process is established and configured, it is now visual information in the Base Map, which is the basis for all location information. An extraction process is required. If the person who wants to search determines the scope of the area and performs a keyword search according to the five sense information classification system already classified through the construction system within that area, all relevant places are delivered as visual information. In the case of outdoors, the basic parcel of the place is extracted, and in the case of downtown, structures having the attributes of the corresponding keyword are extracted and delivered as visual information.

As described above, the technical limitations of tracking the location of the current call are clear. In the situation of initial response to a violent crime, where every minute and every second is urgent and it is important to find a place that fits the report of the reporter as soon as possible, information of the five senses can be used efficiently. The complainant can rely on his or her short-term memory in an extremely stressful situation and talk about everything he or she feels with his five senses. The expression of the place delivered through the report of the reporter

It may be limited, but if the information of the five senses expressing the place is mixed in the content, even within the technical limitations of location tracking, it will be matched with all building information within the error range, and the building that has the five sense information delivered by the reporter will be selected first, which is It acts as a filter for information. By determining the priority location of the scene investigation, the dispatch police will be able to reach the victim in the fastest time possible.
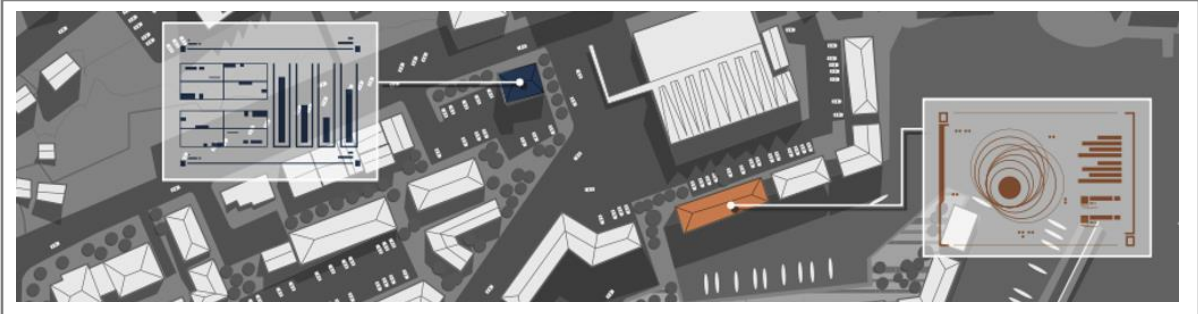

Figure 6 Attribute information mapping

2.2.3 Filtering of information

If information on the five senses is additionally built in the administrative information about the place, there is no special difference in the visual information about the place. However, with the attribute information already linked through additional information, the five sensory information about the actual place is mapped with the visual place information on the map. Spatial information about a place is prepared like this
It goes through the process of tracking the location according to the contents of the report and extracting keywords that refer to the place among several keywords mentioned in the contents of the report in the process. Through the process of filtering a lot of information into key information, candidates for the most prompt and closest target location are set up, which saves a considerable amount of time for efficient operation and life-and-death from the point of view of the reporter and the situation room or the police dispatched to the scene. It plays a role in saving precious minutes and seconds that can come and go. Just as impurities are filtered out through a funnel and high-quality desired results are obtained, it will be possible to reach the destination at the moment and time when it is most needed through the filtering process of language information and the mapping of existing spatial information.
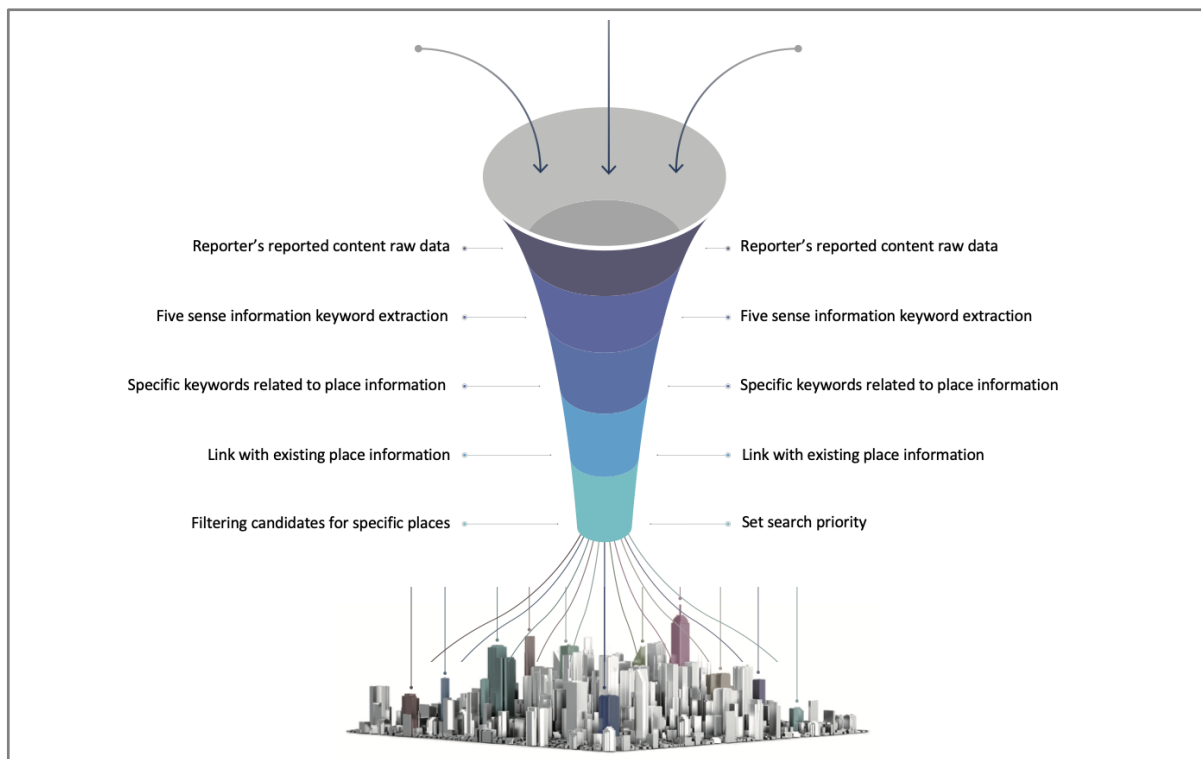

Figure 7 Information filtering

2.3 On-site dispatch using five sensory information

The entire dispatch process is as follows. The basic condition is a state in which the five sense information is tagged for all place information in the experiment target area. Reports come first. The report is normally received at the 112 General Situation Room, and the police officer in charge asks the reporter the most basic questions. Ask about the reason for the call, current situation, current location, etc.

In response to the questions asked, the complainant will deliver the contents that can be expressed and answered in the current situation. All transmitted contents are recorded and all voice messages are recorded in text form. Depending on the severity of the current situation during the conversation, a situation arises in which consent is obtained for location information or unconditional tracking without obtaining consent. First of all, when location tracking is started, the place where the current call is received is displayed on the map of the police general situation room. The location at this time is tracked by Cell, GPS, and WIFI as described above. The positional error has a minimum error range that has already been studied.

Now, through the text analysis of the reported content, words or sentences that express the place are extracted from the reporter's reported content. In the case of accurate administrative information, it is possible to search the location immediately. Even if the content reported by the reporter is delivered as information by the five senses, it is converted into the most standardized word by complying with the standard system expressed by the five senses through natural language processing techniques. Now, in the reporting range on the map that has errors, the information of the five senses analyzed by the keyword of the reporter is matched, and all places with the corresponding conditions within the range are extracted. The police officer in charge will share the most likely suspect location with the dispatch team and issue an order. Now, the field dispatch team will share the report, set an access route to the site based on the command issued by the general situation room, and proceed with the investigation alone or in collaboration with other field teams. It is to find the location of the final reporter.

Although the above situation is a hypothetical story, the establishment of actual five-sensory information and the linkage of existing spatial information are very key elements in the entire process of all crimes occurring and dealing with, such as actual victim reporting situations and police dispatch situations. It will be.

In the hypothetical mobilization scenarios listed above, it can be said that the key is prioritization and minimization of potential on-site suspect sites. The solution to a horrific crime scene situation would be to prevent it from happening in the first place, but not all situations are under human control. Therefore, it is very important that the police arrive at the scene as much as possible when a situation arises.

Pre-construction of five sensory information and connection with existing place information are very important factors that can support this core. It is essential to consider in advance the situation of the victim who has no choice but to rely on extreme stress and short-term memory, predict possible expressions, and connect with spatial information of an early place.

Figure 8 On-site dispatch procedure

3. Infinite expansion of five sensory information

We live in a highly informational society. The 4th Industrial Revolution and the development of information technology are continuously and rapidly changing the face of our society. In particular, the concept of big data transformed existing document-oriented information into various forms such as video, photo, and voice. It is sensitive to change and overflows with information of various expressions, but the basis of all information is ultimately determined by humans and created by human judgment. In particular, information on places that are closely related to our lives should be made of the most realistic collection of information faithful to the basics. In addition, when the five sensory information that humans instinctively feel is added, communication about the place can be felt more efficiently in various emergency situations.

People's safety is not only about being protected from crime. People have the right to be protected from any threat to their safety. No, they must be protected. I think that the world has become a better place to live in because it has become economically and technologically advanced.

It is an illusion. It can be said that the world is a good place to live only when it is free from elements that threaten safety. The day when all countries become safe countries will surely come.

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