

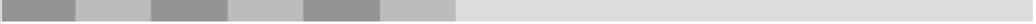
## ABSTRACT

# Guideline Development of Design and Operation of the Video Security System for School Safety

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|-----------------|--|
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The purpose of the present study was to solve various problems occurring due to the lack of installation plans for image security systems installed in school facilities and the formation of inappropriate monitoring environments in order to form safe school environments for students. To this end, the present study was conducted to provide reference data so that school users can obtain CCTV system related knowledge and design CCTV systems to fit school characteristics.

The present study is composed of literature review, crime characteristics analysis, actual state survey & analysis, and simulation stages. In the literature review stage, major advanced countries' security system related policies and image security system related domestic/foreign previous studies were analyzed to investigate elements such as resolution and installation locations that should be considered in the stages of CCTV system design and operation. In the crime characteristics analysis stage, major schools where crimes occurred, time points of occurrence, and places of occurrence of crimes in schools and around schools(kidnapping, theft, sex crime) were analyzed to derive prerequisite conditions that must be considered for each space when school CCTV systems are designed to respond to criminal acts. In the actual state survey and analysis stage, prior

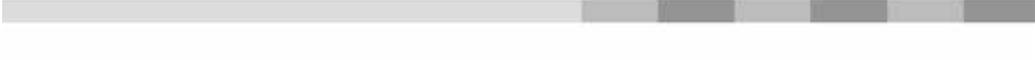


on-site visit surveys of representative cases comprising a total of six schools(3 elementary schools, 2 middle schools, and 1 high school) were conducted. In this stage, the actual states of CCTV system design and operation for spaces derived in the crime characteristics analysis stage (school gates, school building entrances, etc.) were investigated and analyzed centering on the classification criteria (CCTV camera performance, CCTV system installation and monitoring environment) identified through investigation in the literature review stage to derive matters to be improved. In the simulation stage, case schools having school environments such as representative school facilities and schoolyards were selected and CCTV cameras were installed to establish guidelines by CCTV system element and CCTV camera installation criteria by school space as well as developing models of security offices that are CCTV monitoring spaces. In addition, to help school fields' understanding of the guidelines, an “image security system(CCTV) installation and operation guideline for students' safety” was developed as shown in appendix 5 and an English version (appendix 6) was also developed to enhance the international status of the implementation of school safety related policies.

### **1) Comparison and analysis of major advanced countries' image security system related policy trends**

In the present study, image security system related policies and cases in advanced countries; the UK, the USA, and Japan were analyzed and in the case of the UK where CCTV systems are the most widely utilized, excellent schools and related institutions were visited to investigate and analyze policy trends and actual states more in detail.

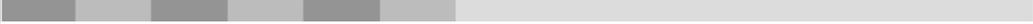
In the UK, personal information(including video information stored in CCTV systems) is thoroughly managed through the “Data Protection Act” established in 1998. In addition, private security guards' qualification system operation related



laws were established through the “Private Security Industry Act” in 2001. The relevant act stipulates that an institution named “Security Industry Authority” should be established to perform works such as qualification system operation, education, and certificate issuing. In addition, the “Protection of Freedom Act” stipulates that guidelines for monitoring camera systems should be developed to make effort for effective CCTV system operation. Based on these laws, the Scientific Development Branch of the Home Office of the UK develops CCTV system related guidelines and the “Security Industry Authority” manages security guards’ qualifications.

In the USA, the “Safe and Drug-Free Schools and Communities Act” under the “No Child Left Behind Act of 2001” which is an elementary and middle school education act amended in 2001 suggests to install security equipment such as surveillance cameras and metal detectors as means of ensuring student safety by preventing school violence and drug taking and the “School Security Technology and Resource Center” was established as an institution specialized in school security that plays roles such as the evaluation of the performance of school security, technology development, and technical support. In addition, the “Department of Homeland Security(DHS)” was established pursuant to the “Homeland Security Act of 2002” and the DHS established the “Federal Emergency Management Agency” to play diverse roles such as reinforcing security in important facilities including schools, training, and budget support.

In Japan, social perception of the necessity of prevention of school crimes increased due to shocking crimes conducted on students in 1999 and 2001. In response, through actual state surveys utilizing diverse experts for one year, the Ministry of Education, Culture, Sports, Science and Technology developed a guideline named “Regarding school security facility security measures” containing contents such as access control reinforcement, electric power and security monitoring systems for securing visibility, and standards for lightings by applying



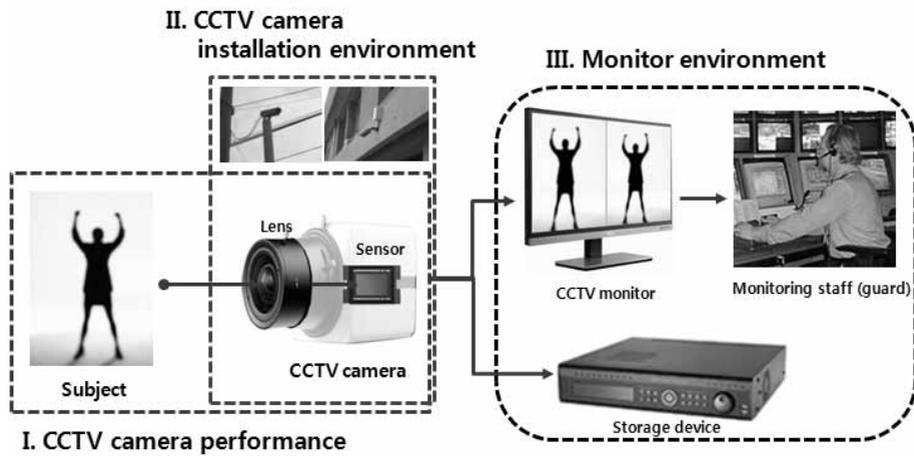
the 2002 crime prevention environment design. In addition, along with the implementation of the “supplementary project related to school facility safety management”, the “guideline for elementary/middle school facility maintenance” was amended in 2003 to introduce school security systems such as anti-crime measures for school facilities, anti-crime surveillance systems, and information systems. Along with the implementation of such diverse projects, the Ministry of Education, Culture, Sports, Science and Technology published in 2004, a “research study report regarding school facility security measures” related to school facility security measures containing details such as the kinds and characteristics of CCTV systems and the kinds of storage devices and the educational facility research center of the National Institute for Educational Policy Research under the umbrella of the Ministry of Education, Culture, Sports, Science and Technology published and supplied a “school facility anti-crime measure casebook” in 2006.

## **2) Analysis of image security system related previous domestic/foreign studies**

In the part of previous study analysis, a total of seven pieces of CCTV system related literature in Korea, the UK, the USA, and Japan as follows were analyzed; ‘Analysis of the effectiveness of school and around school CPTED(Park Seong-Cheol and six others, 2010)’, ‘A study of school safety improvement measures for the formation of safe school environments(Park Jun-Seok and eight others, 2013)’, ‘A guideline for the construction of integrated control centers(National Information Society Agency, 2011)’, ‘Secured By Design Schools(Association of Chief Police Officers, 2010)’, ‘The Appropriate and Effective Use of Security Technologies in U.S schools(U.S Department of Justice, 1999)’, ‘CCTV Operational Requirements Manual(Home Office Scientific Development Branch, 2009)’, and ‘Introduction of monitoring systems(Ministry of

Education, Culture, Sports, Science and Technology of Japan, 2002).’

The contents derived through the analysis of previous studies can be largely divided into three groups as shown in [Figure 1]. The first group is regarding CCTV camera performance comprising CCTV resolution, visibility that is determined by view angles, and effective ranges of monitoring, the second group is regarding CCTV camera installation environments that refer to the importance of the height and location of CCTV cameras installed, and the third group is regarding monitoring environments such as the sizes and partitions of CCTV monitors and screens and the sizes of security offices.



[Figure 1] Factors derived through the analysis of CCTV system related previous studies

<Table 1> CCTV system related previous studies and major contents

No.	Author	Major contents
1	Park Seong-Cheol et al.	· CCTV camera performance · Monitoring environment
2	Park Jun-Seok et al.	· Number of CCTV cameras installed · CCTV camera performance · Monitoring environment · Security office
3	National Information Society Agency	· Monitoring environment

No.	Author	Major contents
4	Association of Chief Police Officers	· Lighting · CCTV camera performance · CCTV camera installation environment
5	U.S Department of Justice	· CCTV camera performance · CCTV camera installation environment, · Lighting
6	Home Office Scientific Development Branch	· monitoring environment · CCTV camera performance · Lighting
7	Ministry of Education, Culture, Sports, Science and Technology of Japan	· CCTV camera performance · Monitoring environment

To review limitations in the factors derived through the analyses of individual previous studies, first, with regard with CCTV camera performance, although the previous studies recommended to use CCTV cameras with the picture quality of at least one million pixels, it is not clear as a standard for CCTV camera installation because it does not reflect the view angles of CCTVs for filming, focal distances, or the validity of image interpretation. Second, with regard to CCTV camera installation environments, although previous studies mentioned CCTV camera installation heights(at least 5.5m) and camera angles(box type camera angle 80°, dome type camera angle 50°), they did not present standards applicable to school fields. The contents of the existing guidelines are not sufficient for application to school fields. Third, with regards to monitoring environments, although storage device related contents (rough calculation formulas, recommended capacity for 30 days, etc.) and standards for the number of monitor screen partitions, etc. are presented, the survey indicated that detailed standards should be calculated such as storage device capacities according to the number of CCTV cameras and monitor sizes and partitions considering monitoring security guards' physical abilities.

### 3) Analysis of the characteristics of crimes in schools and around schools

Among crimes that may occur in schools or around schools, only those cases that may be conducted by outsiders were selected and those cases that were actually prosecuted as criminal cases and convicted at least at the first trial were analyzed. The total number of written judgements collected using the keywords, 'school' and 'around school' was 1,443 comprising 103 kidnapping cases, 499 theft cases, and 841 sex crime cases and when the cases were filtered to select only cases related to schools or people around schools, 36 kidnapping cases, 188 theft cases, and 592 sex crime cases were identified.

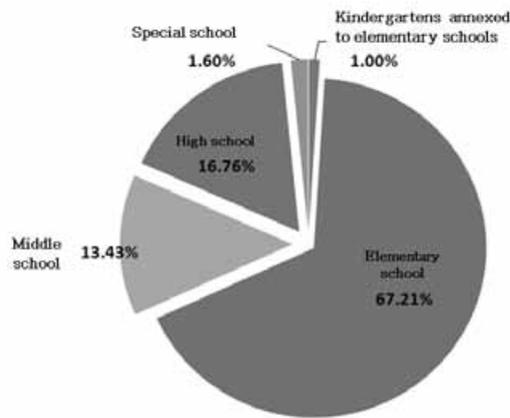
〈Table 2〉 Data used in the analysis of the characteristics of crimes

Division	Content
Analysis data	Written judgment at the first trial or thereafter
Kinds of crimes	Number of cases(year and number of cases of collected written judgements)
Kidnapping cases*	36 (Jan. 2004 ~Dec. 2013, number of collected written judgements 103)
Theft cases	188(Jan. 2010 ~Dec. 2013, number of collected written judgements 499)
Sex crime cases	592(Jan. 2010 ~Dec. 2013, number of collected written judgements 841)

\* In the case of kidnapping cases, written judgements in 2004~2013 were collected and analyzed because the number of cases occurred was small.

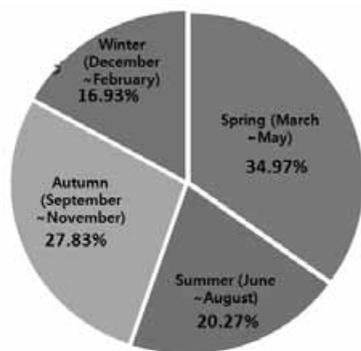
To derive the characteristics of crimes that must be considered in the stages of CCTV system design and operation, the characteristics of crimes were divided into 'schools where crimes occurred', 'time or hours of crimes', 'the scenes of crimes', 'matters related to victims- assailants', and 'other things significant to report' to analyze them.

According to the investigation of the ratios of crimes occurred by school grade, elementary schools showed the highest ratio (67.2%) indicating that the prevention of crimes on elementary school student is urgently needed.

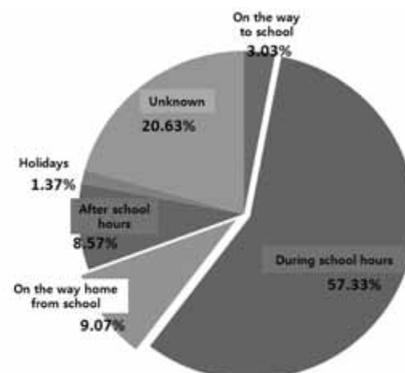


[Figure 2] Crime rates by school grade

To review ‘the times and hours of occurrence’ of crimes by school grade, with regard to crimes occurred by season, 34.97% of crimes occurred in spring (March~May) and 27.83% of crimes occurred in autumn (September~November). With regard to crime rates by hour, 57.33% of crimes occurred during school hours and 9.07% of crimes occurred on the way home from school indicating that measures to prevent crimes during the periods of school operation and during daytime should be established.

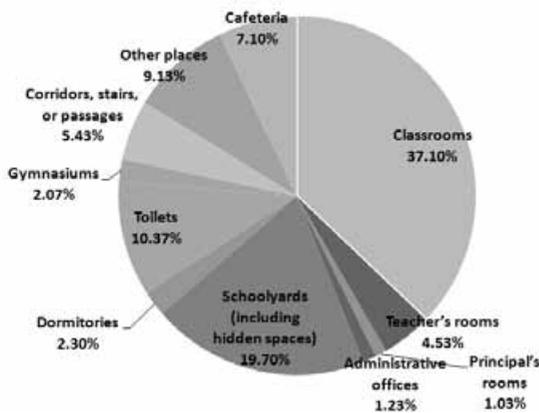


[Figure 3] Times of occurrence of crimes

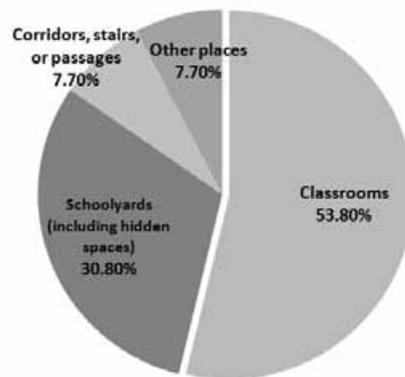


[Figure 4] Hours of occurrence of crimes

To review the 'scenes of crimes' by school grade, 37.1% of crimes occurred in classrooms, 19.7% of crimes occurred in schoolyards (including hidden spaces), and 10.37% occurred in toilets. In the case of kidnapping among crime types, 53.7% occurred in classrooms and 30.8% occurred in schoolyards (including hidden spaces). Therefore, it can be seen that most crimes occur in classrooms and schoolyards (including hidden spaces).



[Figure 5] Scenes of crimes



[Figure 6] kidnapping cases

To review matters related to victims–assailants in kidnapping cases, theft cases, and sex crime cases, female victims were approximately 2,6 times more frequent than males victims as 25,9% of victims were males and 67,9% of victims were females and male assailants were approximately 6 times more frequent than female assailants as 86% of assailants were males and 14% of assailants were females. With regard to victim–assailant relationships, 57,7% of assailants were strangers, 16,7% of assailants were school employees, and 12,2% of assailants were victims' acquaintances and most of the assailants as school employees were in sex crime cases.

〈Table 3〉 Victim–assailant related matters

Division	Content	Remark
Victims' genders	Male 25.9%, female 67.9%	
Assailants' genders	Male 86%, female 14.0%	Female assailant (Special school sex crime)
Victim–assailant relationships	Stranger 57.7%, school employee 16.7%, victims' acquaintances 12.2% etc.	School employees (sex crime cases)

To review other things significant to report, unlike theft cases and sex crime cases, many kidnapping cases were accompanied by concurrent crimes. Out of the 34 kidnapping cases, 24(66.7%) were accompanied by concurrent crimes and the concurrent crimes included eight cases(33.3%) of sexual violence and five cases (20.8%) of assault. In the case of theft cases, out of the 188 cases in total, 181(96.3%) were crimes of trespassing and of the 181 cases of crimes of trespassing, 163(86.7%) were cases where the assailants broke into unlocked school buildings to commit the crimes. One thing significant to report regarding sex crime cases is that victims had disabilities in 99(26.9%) out of the 368 sex crime cases in total. To review in detail, the victims had physical disabilities in 5 cases (1.4%) and intellectual disabilities in 94 cases(25.5%). Therefore, students with intellectual disabilities were victims in one of every four school sex crime cases.

〈Table 4〉 Other things significant to report by crime type

Division	Content	Remark
Kidnapping	Concurrent crime incidence rate 66.7%	Sexual violence(33.3%), assault(20.8%)
Theft case	Crime of trespassing 96.3%	Open door (86.7%)
Sex crime case	Victims with disabilities 26.9%	Intellectual disabilities(25.5%), Physical disabilities(1.4%)



Through the analysis of crime characteristics, objects and schools vulnerable to school crimes and the times and places of occurrence of crimes could be seen and the results of the analysis indicated that to prevent school crimes, various crime prevention strategies should be established such as increasing the number of CCTV systems and the roles of school security guards, reviewing monitoring places and methods for school safety, CCTV monitoring functions, and ethical education of school officials.

#### **4) Survey and analysis of actual states of image security systems for school facilities**

The analyze the present state of and problems in the installation·operation of CCTV systems in domestic school facilities, actual state surveys and analyses were conducted. The object schools of the actual state surveys were selected from among schools in which CCTV systems were in security offices and many CCTVs were installed. Considering school grades with high levels of the necessity of crime prevention based on the results of analysis of crime characteristics, three elementary schools, two middle schools, and one high school were selected and CCTV camera performance, the present state of CCTV cameras installed, and monitoring environments which are security level classification criteria derived through the literature review were investigated in these schools.

As shown in <Table 5>, for CCTV camera performance, the degrees of recognition of humans/objects in images taken through CCTVs according to the resolutions of CCTV cameras installed were examined and for the present situation of CCTV cameras installed, the arrangement and heights of CCTV cameras and resultant images taken were analyzed. For monitoring environments, the sizes and number of partitions of CCTV monitors and resultant degrees of face recognition, security guard related matters such as the number of security guards and security works, and security office designs were investigated and analyzed.

〈Table 5〉 Major contents of actual state surveys

Division	Content of questionnaire
CCTV camera performance	CCTV cameras' number of pixels, degrees of recognition of humans/objects
Present state of CCTV cameras installed	CCTV camera arrangement and height
Present state of monitoring	Monitor sizes and the number of partitions, maximum/minimum sizes of humans, face recognition, security guard related matters, security office designs, etc.

To analyze CCTV camera performance, images taken and stored by CCTV cameras were divided by the 6-point Lickertis scale as follows and the adequacy of the images was evaluated. Among Lickertis scale scores, “0 point” is for cases where the object is seen as a point or vaguely, “3 points” is for cases where the face of the object can be vaguely recognized, and “5 points” is for cases where human faces can be clearly recognized.

〈Table 6〉 Face recognition measurement scale(Evaluation of the adequacy of images taken)

Scale	Content	Scale	Content
0	Humans are indicated as points or vaguely	3	Faces can be vaguely recognized
1	Whether or not humans appear can be identified	4	Faces can be recognized
2	Whether each human is an adult or a child can be identified	5	Faces can be clearly recognized

To review CCTV camera performance, when images taken by CCTV cameras in schools of which actual states were investigated were checked, the objects of imaging could not be identified in the case of most schools because CCTV cameras with low resolution at approximately 410,000 pixels were installed as shown in Figures 7 and 8. High resolution cameras installed in the schools were filming

objects at too long distances leading to low efficiency of the cameras and ineffective monitoring(Figure 8). In addition, most CCTV cameras did not support infrared ray functions for night filming so that only the outlines(whether there are humans or not) of humans can be identified from images taken at night (Figure 10).



[Figure 7] Low picture quality  
image(410,000 pixels)#1



[Figure 8] Low picture quality  
image(410,000 pixels)#2



[Figure 9] Image taken at a long  
distance(2,000,000 pixels)



[Figure 10] Image taken at  
night(2,000,000 pixels)

When the present state of CCTV cameras installed were reviewed, most schools showed problems such as filming the upper part(Figure 11) of humans' heads due to CCTV cameras installed too high as shown in [Figure 12]or the objects of filming seen too small because they were filmed at too long distances such as filming the entire school yard from the outer wall of the fourth floor of the building(Figure 13) because CCTV camera installation locations and heights were

not properly considered. In addition, CCTV cameras installed at the doors of school buildings were installed on the outside of the doors as shown in [Figure 14] creating many blind spots.



[Figure 11] CCTV camera installed at a height of a 3rd floor



[Figure 12] Filming image(Figure12)



[Figure 13] Image of a schoolyard taken



[Figure 14] CCTV camera at a school building door

To review monitoring environments, the sizes of CCTV monitors installed in the security offices of the six object schools were 19 inches on average and the numbers of monitor screen partitions were at least 12 on average. Due to too many partitions in small monitors of approximately 19 inches, the faces of the objects of filming in each screen could not be properly identified(Figures 15, 16). Although varied greatly according to the number of CCTV cameras per storage device and the number of pixels of cameras, when estimated based on 400,000

pixel CCTV cameras, storage spaces for images taken by CCTVs held by the schools were sufficient only for images taken for approximately 15 days, much shorter than the specification recommended by the Ministry of Education which is 30 days. Finally, to review security office environments, there problems in the areas of security offices, CCTV monitor arrangements, and door designs. The areas of security offices were not enough to arrange diverse articles furnished and the locations of CCTV monitors were poorly selected to include the top surface of the shelf or the refrigerator as shown in [Figure 17] making monitoring work inefficient. In the case of security office door and window designs, although transparent ones that can secure monitoring views are recommended, most schools showed a problem that these had been designed as closed types(Figure 18).



[Figure 15] CCTV monitor(36 partitions)



[Figure 16] CCTV monitor(16 partitions)



[Figure 17] CCTV monitor arrangement(inappropriate)



[Figure 18] security office window(closed type design)

## 5) Development of guidelines for image security systems installation and operation through simulations

CCTV cameras that are actually utilized widely in schools were arranged in the experimental object schools and images collected from the CCTV cameras were analyzed to present standards related to CCTV camera performance, CCTV camera installation environments, and monitoring environment and security office models.

For simulations, based on the results of case studies and discussion with experts in related institutions, conditions for CCTV camera pixels(410,000, one million, two millions), focal distances(9.0mm, 6.2mm, 2.8mm), filming distances(5m, 10m, 20m, 30m), and filming spaces(front gate, school building doors, wall, schoolyard, corridor) were set reflecting universal image security design conditions in school fields.

〈Table 7〉 Simulation experimental condition

Division	Content	
CCTV camera performance	Pixel	410,000, 1,000,000, 2,000,000
	Focal distances	9.0mm, 6.2mm, 2.8mm
Filming distances	5m, 10m, 20m, 30m	
Filming spaces	Front gate, school building doors, wall, schoolyard, corridor	

### (1) CCTV camera performance

According to the results of analysis of CCTV camera performance, as can be seen from 〈Table 8〉, there was no big difference in the qualities of images taken by one million pixel and two million pixel cameras. Therefore, rather than expensive two million pixel cameras, one million pixel cameras were shown to be more appropriate.

〈Table 8〉Comparison of image quality among CCTV camera pixels

Division	400,000 pixel	1,000,000 pixel	2,000,000 pixel
Measurement distance (5m)			

〈Table 9〉 shows images taken by one million pixel cameras by filming distance and by focal distance. Through this table, it was identified that, in the case of one million pixel cameras, stable images(at least 3 points) can be obtained if the cameras are installed within 10m from the target point for filming and images are taken with a short focal distance of 10mm.

〈Table 9〉 Analysis of CCTV camera(one million pixel) images by filming distance and by focal distance

Division	Filming distances(CCTV camera - object of filming)		
	5m	10m	20m
Image			
*Evaluation	4 points	3 points	2 points
Division	CCTV camera focal distances		
	2.8mm	6.2mm	9mm

Division	Filming distances(CCTV camera - object of filming)		
	5m	10m	20m
Image			
*Evaluation	2 points	3 points	3 points

\* The evaluation scores are the face recognition index for images shown in <Table. 6>.

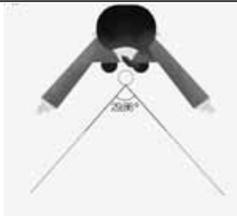
Through these analysis results, it can be seen that the quality of images taken, that is, human recognition varies greatly according to focal distances and filming distances. The results of analysis of the adequacy of images (the level of proving power) are set forth in <Table 10>. All cameras with different levels of resolution(400,000, one million, two million pixels) were analyzed to be capable of obtaining at least 3 points when distances to the object were not longer than 30m if their focal distances were close to 10mm.

<Table 10> Results of evaluation of the levels of proving power secured by simulation condition

Division		Distance to the object(m)			
Resolution (pixel)	Focal distances (mm)	5	10	20	30
400,000	2.8	3	3	2	2
	6.2	4	3	3	2
	9	5	4	3	3
One million	2.8	4	3	2	2
	6.2	5	4	3	2
	9	5	4	3	3
Two million	2.8	4	3	2	2
	6.2	5	4	3	2
	9	5	4	4	3

A formula for calculation of view angles was presented since filming view angles vary with CCTV cameras' focal distances. View angles can be calculated based on major sensor sizes and focal distances referring to the following table. <Table 12> shows view angles calculated based on sensor sizes and focal distances that are mainly used internationally. Since 1/3 inch sensors are mainly applied to schools, horizontal view angles range from 81.2° at the maximum to 29.86° at the minimum and vertical view angles range from 65.47° at the maximum to 22.62° at the minimum.

<Table 11> Calculation of view angles according to major sensor sizes and focal distances

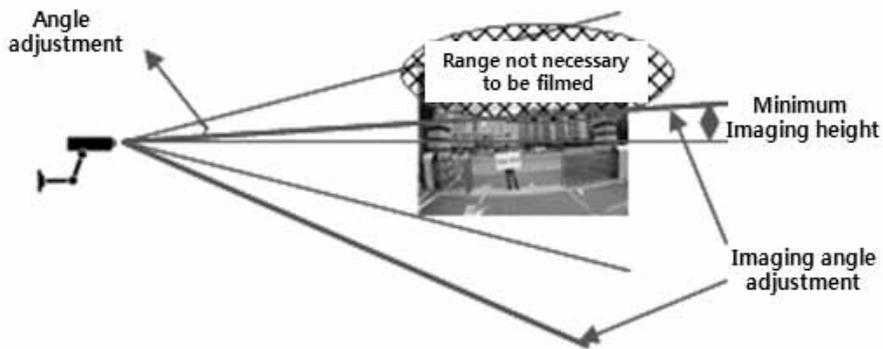
Division	Sensor size(inch) (Width(mm)×length(mm))					Remark	
	1 (12.8×9.6)	1/2 (6.4×4.8)	1/3 (4.8×3.6)	1/4 (3.6×2.7)	1/8 (1.6×0.7)		
Focal distances (mm)	2.8	132.74*	97.63	81.20	65.47	31.89	 <p>※ Rough measuring method utilizing calculated view angles</p>
		119.49**	81.20	65.47	51.48	14.25	
	3.5	122.65	84.87	68.88	54.43	25.75	
		107.80	68.88	54.43	42.18	11.42	
	5	104.00	65.24	51.28	39.60	18.18	
		87.66	51.28	39.60	30.22	8.01	
	7.5	80.95	46.21	35.49	26.99	12.18	
		65.24	35.49	26.99	20.41	5.34	
	9	70.83	39.15	29.86	22.62	10.16	
		56.14	29.86	22.62	17.06	4.45	

Note) \*=horizontal view angle, \*\*=vertical view angle

## (2) CCTV camera installation environment

With regard to CCTV camera installation environments, if CCTV cameras are installed too high, only the top of humans' heads will be shown and problems occur in recognizing humans and if they are installed lower, blind spots will decrease but actual filming distances will be shortened. Therefore, according to investigations, cameras should be installed as low as possible and should not exceed 7.5m and focal distances should be set at least 5mm to secure effective

camera angles for effective monitoring. In addition, to reduce blind spots of CCTV cameras and avoid filming only the top of the head, the angle of CCTV cameras should be adjusted as shown in [Figure 20] to arrange CCTV camera angles between  $30^{\circ}$  and  $45^{\circ}$  ensuring that the CCTV camera angles do not exceed  $60^{\circ}$  to be able to obtain effective images.



[Figure 19] Filming ranges according to vertical view angles

### (3) Monitoring environment

Monitoring environments were set based on the face lengths of the objects displayed on the monitor necessary for the monitoring personnel to watch the monitor in real time and perform the desired level of monitoring such as recognizing faces. When measured based on 20inch(width 470mm, length 300mm) monitors that are generally arranged in security offices and the vision of school guards (60s in age), faces could be vaguely recognized when the lengths of faces of images outputted on the screen were at least 10mm and faces could be clearly recognized when the lengths of faces were at least 25mm.

〈Table 12〉 Results of evaluation of the levels of proving power secured by simulation condition

Division		Distance to the object(m)			
Resolution(pixel)	Focal distances(mm)	5	10	20	30
One million	2.8	4*(15**)	3(10)	2(5)	1(2)
	6.2	5(35)	4(15)	2(8)	2(5)
	9	5(50)	5(28)	3(12)	2(8)

Note) \*=Evaluation result, \*\*=face length(mm)

Appropriate numbers of monitor partitions were analyzed based on the results shown in 〈Table 12〉 to derive standards for appropriate screen partitions as shown in 〈Table 13〉. Screen partitions are not appropriate when distances to the objects of filming are 20m or longer and single screens or four partitions are judged appropriate when distances to the objects of filming are 15m or shorter and focal distances are 5mm or longer.

〈Table 13〉 Numbers of screen partitions for appropriate levels of monitoring based on 20inch monitors

Division		Distance to the object				
		5m	10m	15m	20m	30m
Focal distances (mm)	2.8	1*(4**)	(1)			
	3.5	1(4)	(1)			
	5	4(9)	1(4)	(1)	(1)	
	7.5	9(16)	1(4)	1(4)	(1)	(1)
	9	9(16)	1(4)	1(4)	(1)	(1)

Note) \*=appropriate number of partitions, \*\*=Maximum number of partitions

With regard to CCTV systems' storage capacity, a storage capacity calculation formula was presented in the present study and storage capacities according to the numbers of CCTV cameras in operation (5, 10, 15, 20units) and CCTV camera resolution(310,000~two million pixels) for the storage period 30 days recomm-

ended by the Ministry of Education were calculated(Table 14). For instance, the storage capacity necessary for 10 one million pixel cameras is calculated to be approximately 26TB.

(Table 14)Minimum DVR capacities by pixel and by the number of CCTV cameras in operation(GByte)

Division	Resolution		Size of stored images (Gbyte)	Number of CCTV cameras in operation(unit)			
	H	V		5	10	15	20
3,000,000 pixel	2048	1536	0.0000878941569024	34,173	68,346	102,520	136,693
2,000,000 pixel	1920	1080	0.0000579380428800	22,526	45,053	67,579	90,105
1,900,000 pixel	1600	1200	0.0000536463360000	20,858	41,715	62,573	83,431
1,300,000 pixel	1280	1024	0.0000366225653760	14,239	28,478	42,717	56,955
1,200,000 pixel	1280	960	0.0000343336550400	13,349	26,698	40,047	53,396
920,000 pixel	1280	720	0.0000257502412800	10,012	20,023	30,035	40,047
790,000 pixel	1024	768	0.0000219735392256	8,543	17,087	25,630	34,173
480,000 pixel	800	600	0.0000134115840000	5,214	10,429	15,643	20,858
360,000 pixel	800	450	0.0000100586880000	3,911	7,822	11,732	15,643
310,000 pixel	640	480	0.0000085834137600	3,337	6,674	10,012	13,349

#### (4) Standards for CCTV camera installation by space

CCTV camera performance and CCTV camera installation environments were analyzed to establish standards for CCTV camera installation for each of major spaces in schools; ‘school gates’, ‘school wall’, ‘school building doors’, ‘corridor’, ‘schoolyard and hidden spaces’.

① School gate

School gates are places where the importance of CCTV systems for suppressing and monitoring outsiders' trespassing is high. Therefore, appropriate filming ranges that fit the sizes of school gates and the recognition of the faces of filmed objects should be considered.

〈Table 15〉 shows the filming ranges of CCTV cameras widely used in schools according to CCTV camera sensors' focal distances and filming distances. To film school gates of general sizes, 5mm focal distance with 10m filming distance, and 7.5mm focal distance with 15m filming distance are appropriate.

〈Table 15〉 Filming ranges according to focal distances and filming distances based on 1/3inch sensors

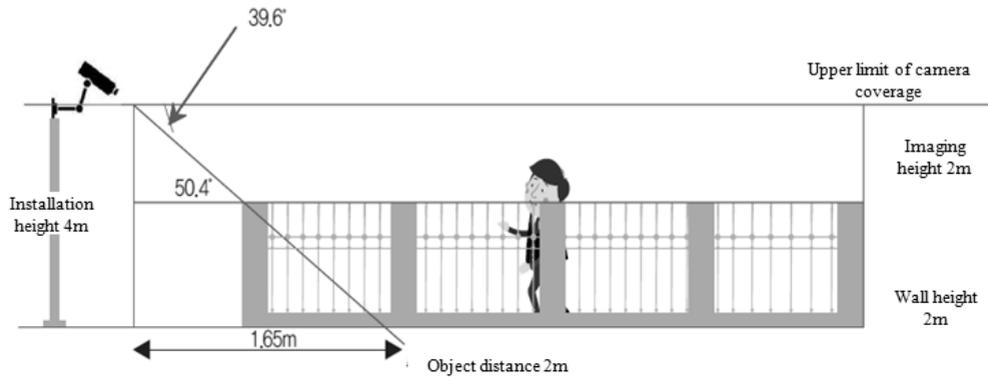
Focal distances (mm)	Distance to the object(m)				
	5	10	15	20	30
2.8	6,429*	12,857	19,286	25,714	38,571
	8,571**	17,143	25,714	34,285	51,429
3.5	5,143	10,286	15,429	20,571	30,857
	6,857	13,714	20,571	27,429	41,143
5	3,600	7,200	10,800	14,400	21,600
	4,800	9,600	14,400	19,200	28,800
7.5	2,400	4,800	7,200	9,600	14,400
	3,200	6,400	9,600	12,800	19,200
9	2,000	4,000	6,000	8,000	12,000
	2,667	5,333	8,000	10,667	16,000

Note) \*=Filming height(mm), \*\*=filming width(mm)

② School wall

Since outsiders trespass through open doors rather than through walls in most cases as can be seen from the characteristic of the crime, the level of monitoring at which only whether or not any outsider trespasses is appropriate. The standards for installation necessary to secure appropriate effective distances for

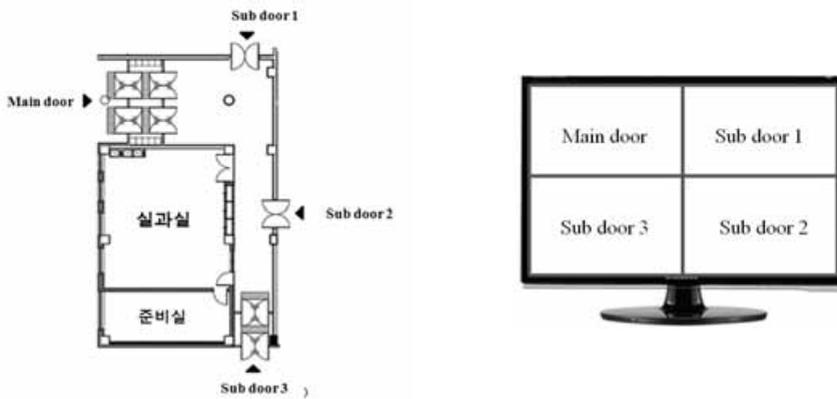
filming and minimize blind spots based on the results of analysis of CCTV camera performance and installation environments are one million pixel CCTV cameras with a focal distances 5mm, a filming distance of 20m, an installation height of 4m(wall 2m, filming height 2m), and a filming view angle of 39.6°.



[Figure 20] Adjustment of camera angles at school walls

### ③ School building door

Since school schoolyards are open and school gates cannot be controlled at all times, school building doors are the most important places for securing students' safety. General school door sizes are not much different among schools and are generally 2.1m×2.0m(H×W). Main doors are 2.1m×4.6m (H×W) in general. Therefore, based on the analysis results shown in <Table 15>, images from which faces can be clearly recognized can be obtained by setting a filming height of 3.6m, a filming width of 4.8m, a filming distance of 5m, and a CCTV camera focal distance of 5.5mm. In addition, when there are four doors as shown in [Figure 21] below, monitoring can be more efficient if a site plan showing CCTV camera locations is attached to each monitor and monitor screen partitions are arranged similarly to door arrangement.



[Figure 21] Example of screen arrangement by door

#### ④ Corridor

In the case of 'corridors', the simulations showed that objects of filming at a distance of 30m could be recognized to some extent based on a one million pixel camera and a focal distance of 9mm. Therefore, considering the condition that corridors are long, setting long focal distances that will enable filming objects at long filming distances is recommended(Figure 22).



[Figure 22] Filmed images in a corridor by filming distance for a focal distance of 9mm

### ⑤ Schoolyard and hidden space

In the case of schoolyard, quite many cameras are necessary to obtain high quality images with a view to recognizing human faces. Therefore, installing an appropriate number of CCTV cameras at the front gate and school building doors and installing a small number of CCTV cameras in the schoolyard to monitor and check only whether or not humans come in or go out is reasonable. Utilizing the results shown in <Table 15>, a 100m long and 50m wide schoolyard can be covered using approximately two CCTV cameras (focal distance 2.8mm, filming distance 30m). [Figure 23] shows an image of a simulation case school in which 2/3 of the area of the schoolyard is observed using one camera(focal distance 2.8mm, filming distance 30m).

In the case of hidden spaces, CCTV cameras should be set to film objects within a distance of 15m based on a focal distance of 5mm as shown in [Figure 24] and among others, installing CCTV cameras low to minimize blind spots is necessary.



[Figure 23] A filmed image of the schoolyard of a case elementary school



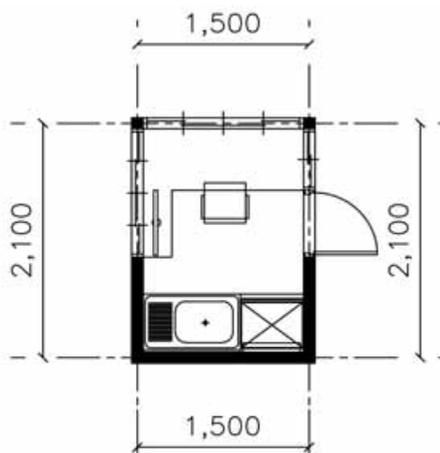
[Figure 24] A case of hidden space CCTV camera installation

### (5) Security office model

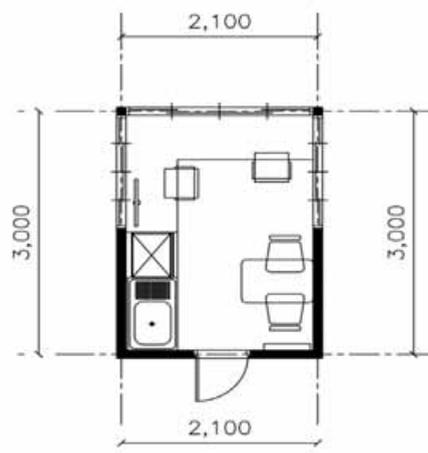
Security offices are an important element in constructing appropriate monitoring environments. In particular, the sizes of security offices are closely

related to the number of monitors installed. Since one or two security guards permanently stay in each school in general, minimum and recommended sizes of security offices were presented based on one person offices and two person offices along with cases of installation of monitors that can be arranged in each office.

[Figure 25] shows a one-person security office model and the size is 1,500mm wide and 2,100 mm long. Inside the office are installed a table, a chair, and a CCTV monitor. [Figure 26] shows a two-person security office model of a 2.1m wide and 3m long size. Inside the office are installed a two-person working table, chairs, a small refrigerator, a wall hanging air conditioner, CCTV monitors, a simple sink, a simple table plus a sink for simple cooking.



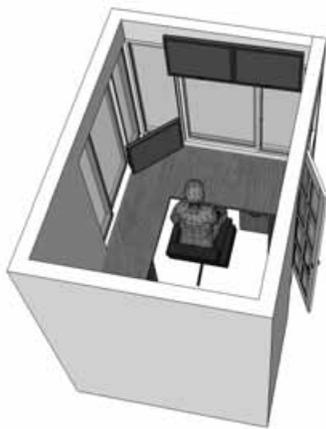
[Figure 25] One-person security office ground plan



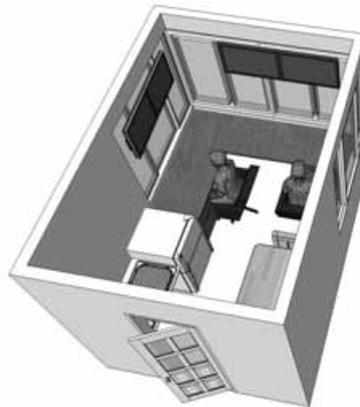
[Figure 26] Two-person security office ground plan

Although up to five monitors can be arranged in the recommended model for one-person security offices, since the number of screens that one person can view is limited (12 monitors), arranging three monitors with four partitions as shown in [Figure 27] enabling simultaneous observation of the outside is

desirable In the case of the recommended model for two-person security offices, monitors can be appropriately distributed according to security guards' locations as shown in [Figure 28] or may be intensively arranged in one place for a guard dedicated to monitoring if available.



[Figure 27] Recommended monitor arrangement for one-person security offices



[Figure 28] Recommended monitor arrangement for two-person security offices

## 6) Policy proposal

If CCTV systems already installed in schools are to be efficiently operated and maintained and new CCTV systems are to be installed, the following strategies are necessary to install and operate those CCTV systems that fit school characteristics.

First, school users have difficulties in understanding the technical characteristics of CCTV systems and perform CCTV system installation and operation work that fits the characteristics of school fields. In addition, replacement of CCTV cameras with high resolution CCTV cameras, replacement and repairs of deteriorated existing CCTV systems will frequently occur. If CCTV systems are added,



replaced, maintained, or repaired without understanding camera performance, installation environments, and monitoring environments necessary for taking and storing images in this situation, the CCTV systems will lose efficiency. Therefore, expert consulting functions are necessary that can connect the characteristics and requirements schools to companies specialized in CCTVs.

Second, in the case of CCTV systems installed in domestic school fields, since relevant projects have been implemented in small scales by individual schools or education offices, cameras that have been broken down are left unattended for more than one month or maintenance services cannot be received quickly small/medium sized CCTV installation companies went bankrupt. To solve these problems, national/regional level management support institutions are necessary. In addition, to establish mid-long-term budget plans and integrated maintenance plans, an integrated management system should be necessary that can identify CCTV systems' performance, years of installation, and operation states in real time.

Third, since teachers or school employees cannot sufficiently perform CCTV system related works and operate CCTV systems because CCTV system operation requires expertise, specialized educational courses for educating on school security system are necessary in university curricula and in the case of existing schools, the persons in charge of CCTV systems should be periodically educated on their works.

Fourth, since CCTV systems were spread in a short period of time, the quantity of CCTV systems to be repaired will intensively increase at a certain time point as the end of service life of CCTV systems comes close. However, since a large amount of budgets cannot be invested in one lot, 1/9 of system costs should be accumulated every year into school accounts or education office accounts considering the service life (9 years) of CCTV systems.

[Table 16] Strategies for efficient installation and operation of CCTV systems

Strategy	Content
1	Effective installation and operation of image security systems through specialized consulting
2	Establishment of integrated maintenance systems for school CCTV systems
3	Operation of specialized educational courses to foster experts in security systems
4	Securing reserves for on-time maintenance

□ **keyword:** school safety, school facilities, school crime, CCTV system, image security systems, image processing device, crime prevention, CPTED, security office