IR HIDING: METHOD FOR PREVENTING ILLEGAL RECORDING OF DISPLAYED CONTENT

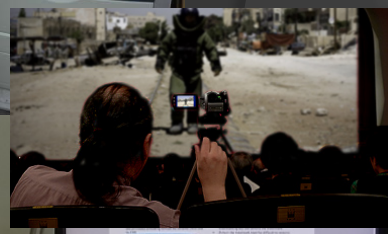
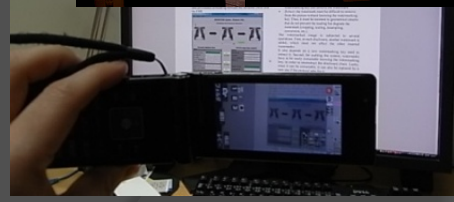
Isao Echizen
National Institute of Informatics
Tokyo, Japan

Background: problems w/content distribution

- Security countermeasures: independently treated in cyber and physical worlds
  - Cyber world: Cryptography
  - Physical world: Property management



- Flaws in countermeasures at border between cyber and physical worlds
  - Conventional IT security cannot stop malicious insider behavior.
  - Analog hole problem
    - Leakage of information in printed documents through illegal copying
    - Displayed content recorded with cell-phone camera
      -> recorded content uploaded

- Our aim: Establish security countermeasures at border between cyber and physical worlds.

Analog hole problem

Conventional problem

- Insufficient security on analog-output terminals of digital equipment
- Overcome by replacing them with digital ones

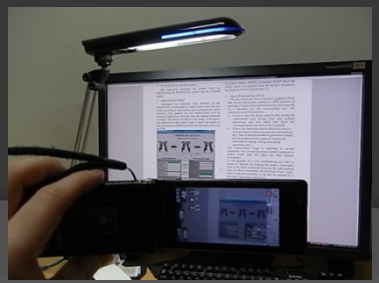
Rise of new problem exploiting monitors and screens

- Growth and increasingly high quality of monitors and cameras

  -> Make it easy to illegally record and distribute content
  - Record content displayed on PC monitor with cell-phone camera -> upload recorded content
  - Record movie shown on theater screen -> sell pirated DVDs
- Improvements to and widespread use of printers

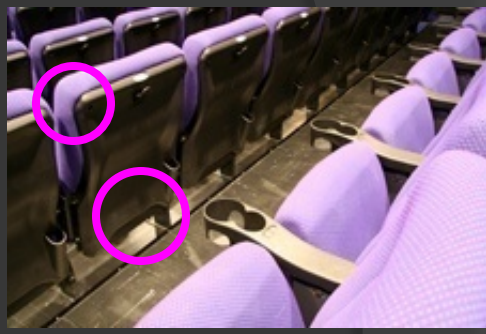
  -> Make it easy to illegally copy and leak information on printed documents

  About half of information leaks occur via paper documents (Japanese NPO surveys)



Pirating at movie theaters

- Recording is done by
  - Fixing camcorder on cup dispenser of seat
  - Pinching camcorder between backrests of seats directly in front

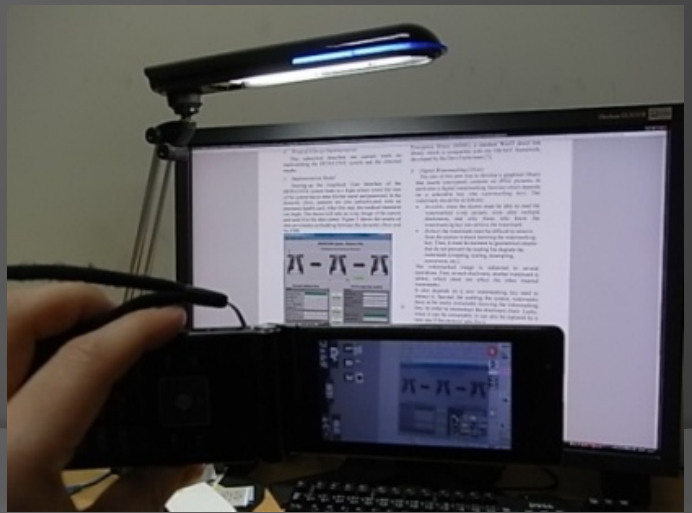


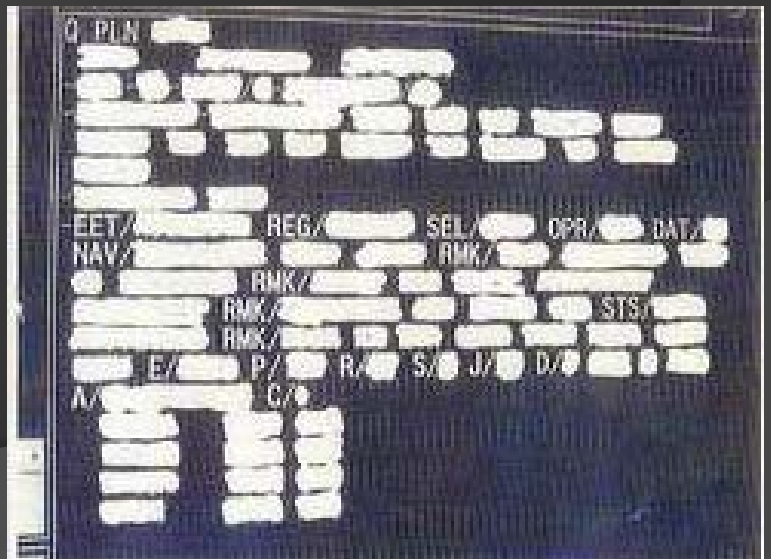
- Bootleg films recently re-shot (in Japan)
  - Ponyo: leaked to Chinese video-sharing site two weeks after release (July 2008)
  - Rebuild of Evangelion: leaked to Chinese video-sharing site three weeks after release (June 2009)
  - Harry Potter and the Half-Blood Prince: leaked through file-sharing software “Share” (August 2009)

- Damage
  - Damage caused by bootleg film recording: 3 billion dollars/year (according to American Film Institute)
  - Damage caused by re-shooting at theaters (in Japan): 200 million dollars/year (in 2005)

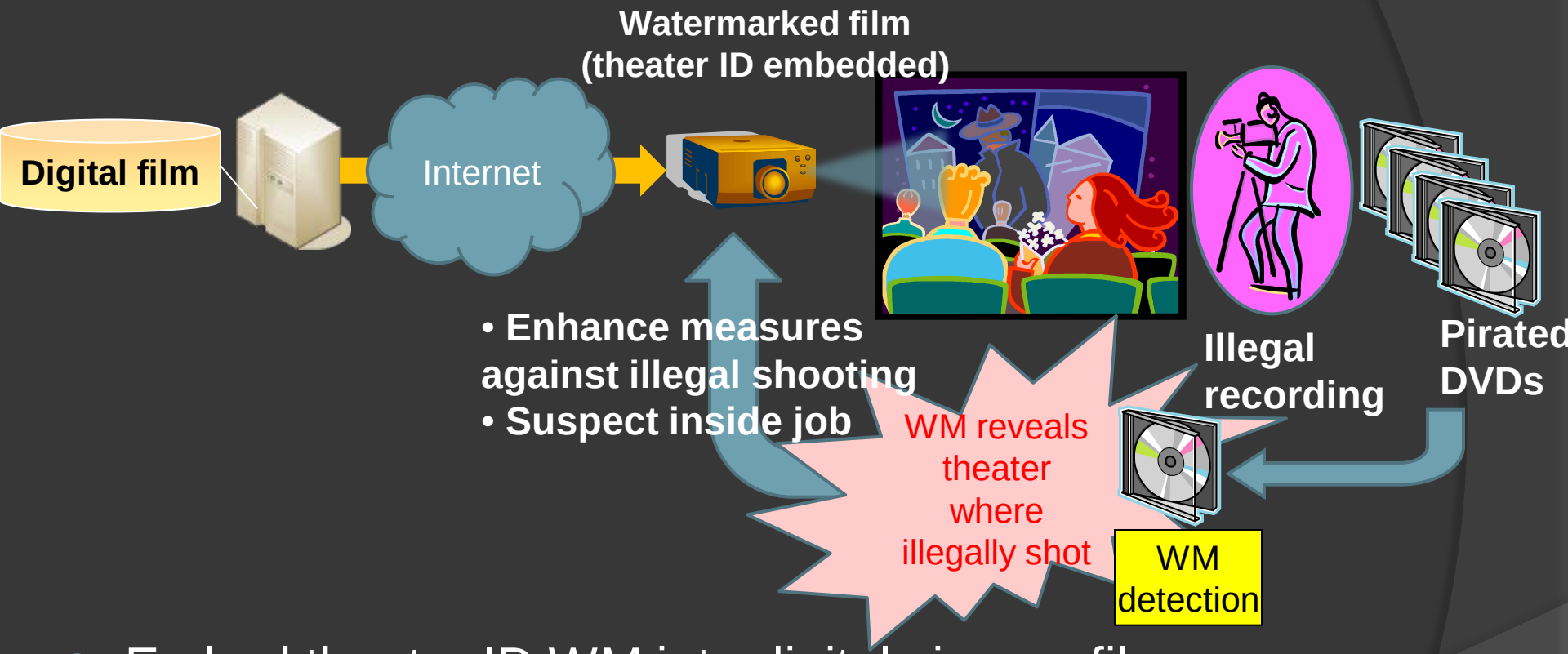
Disclosure of confidential/personal information through displays

- Record images displayed in public institutions and enterprises
  - Staff members at medial facilities photographed displays showing patient records and used images for external presentation (Saiseikai Utsunomiya Hospital, March 2008).
- Government/corporate/military secrecy: more serious
  - Airport traffic controller photographed displays showing flight plan for Air Force 1 (Haneda International Airport, September 2011)





Conventional measures against re-recording: Digital watermarking



- Embed theater ID WM into digital cinema film.
- Detect WMs in pirated DVDs and identify flow of illegal distribution.

But: no control of re-recording

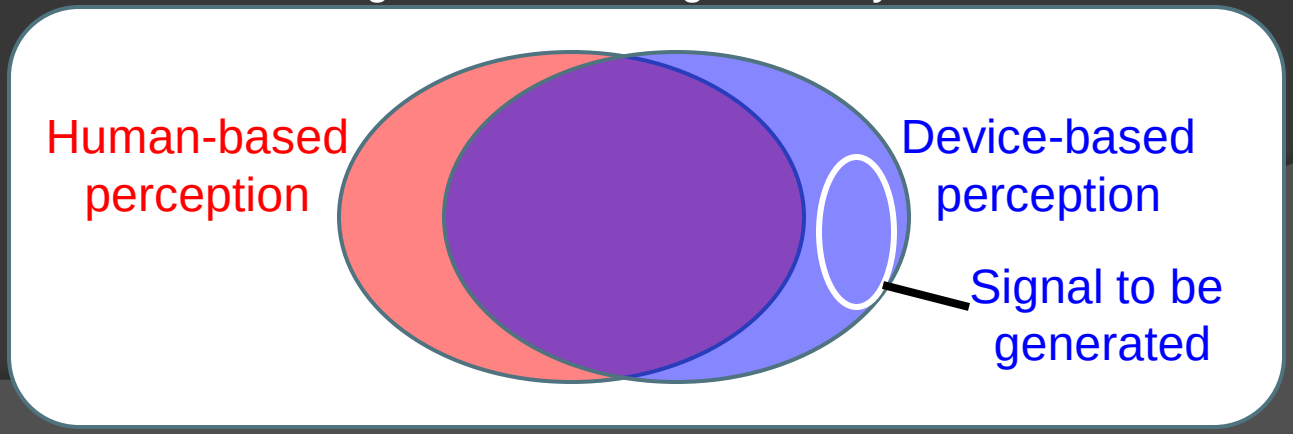
IR Hiding: Method for preventing illegal recording of displayed content - Objective and approach -

Objective:

- Establish countermeasures to stop illegal recording of displayed content
  - No new functions should be added to existing user-side devices (ex. cam)

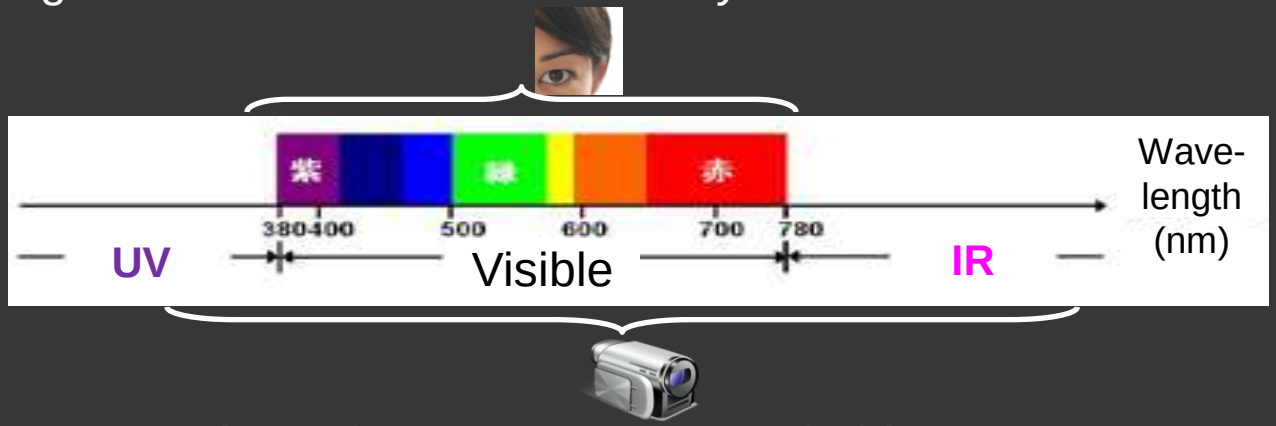
Approach:

- Exploit difference between sensory perceptions of humans and devices
  - Destroy shot content using invisible signals that add noise to content shot through CCD/CMOS devices
    - Use near-infrared signals as noise signals: Only CCD and CMOS react to them



Properties of noise signals

- Wavelength of noise signals
  - Visible range of human eye: 380–780 nm
  - Visible range of CCD/CMOS devices: 200–1100 nm
    - Consumer camcorders react to signals with wavelengths outside human visible range in order to maintain sensitivity in dark environments.



Ultraviolet: can cause serious damage to eyes and skin

Infrared: used in various consumer devices

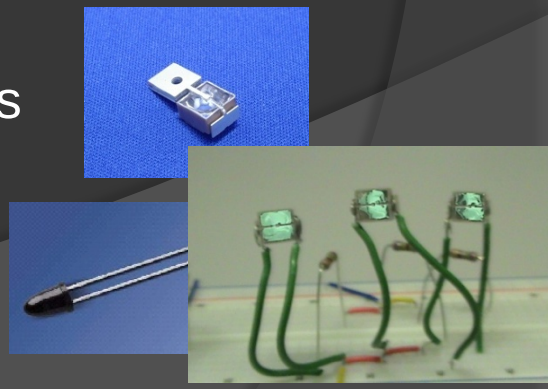
IR light emitters: lasers, diodes, xenon/halogen lamps

-Safety: not harmful to humans

-Radiation angle: effective at any display angle

-Cost effective, easily replaced

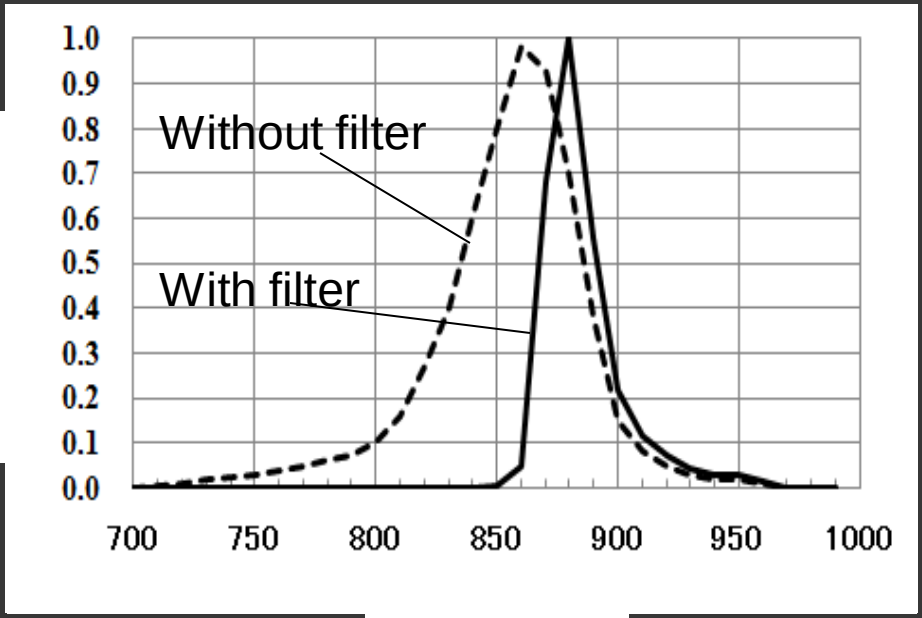
Use near-infrared LEDs



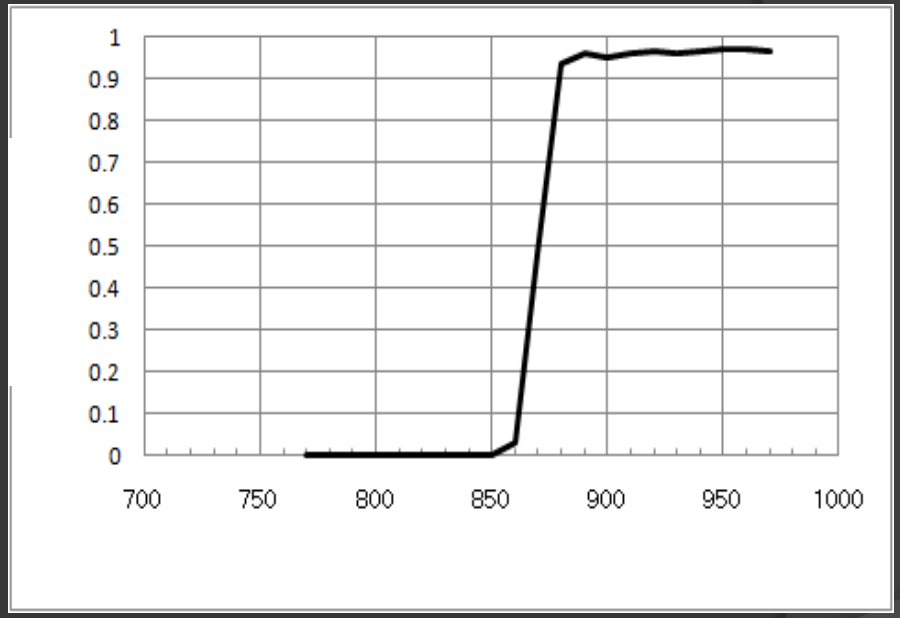
Near-infrared LEDs

Measures against visual degradation: Short-wavelength cut filter

Near-infrared LED
(peak wavelength: 870 nm)



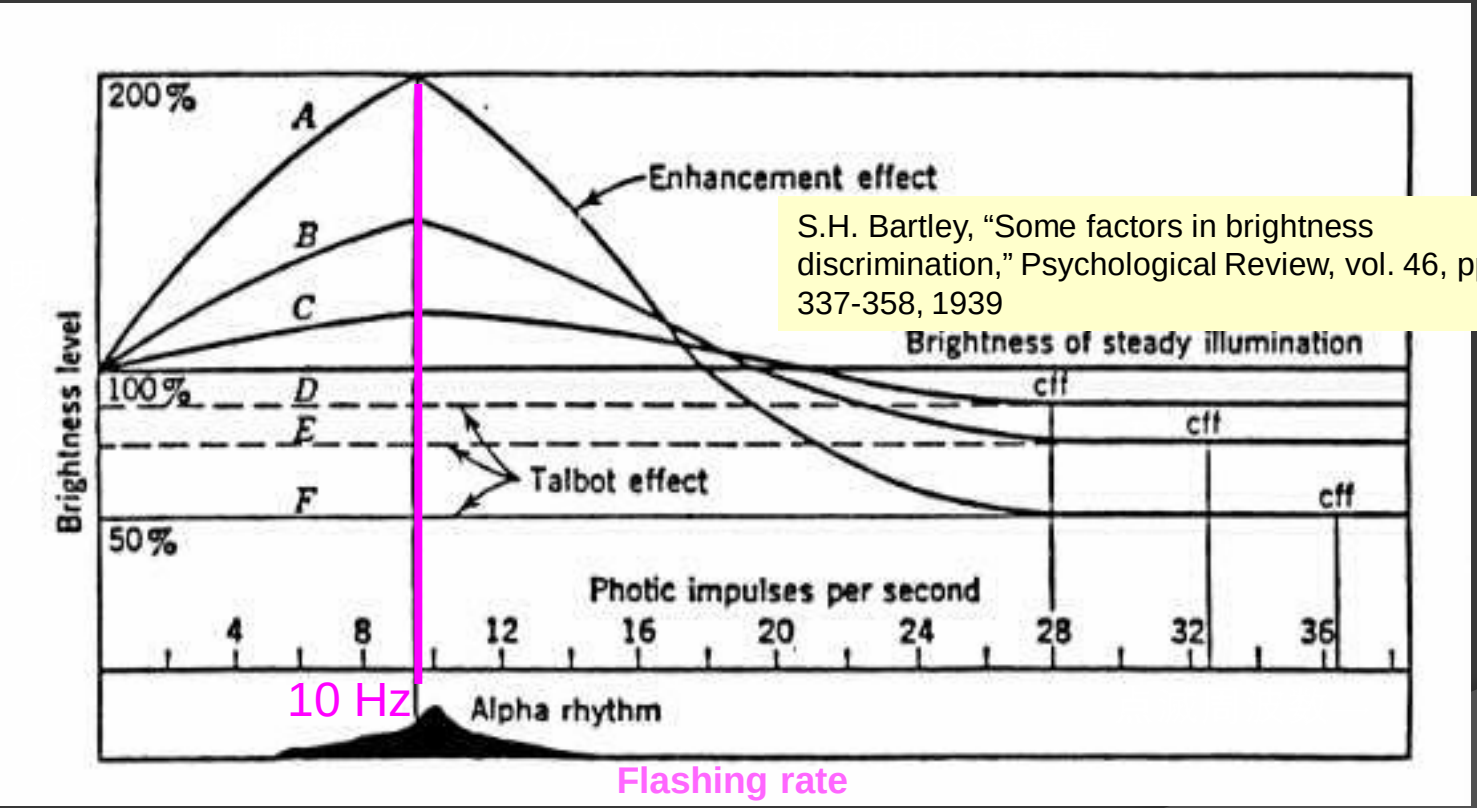
Short-wavelength cut filter
(cut-on wavelength: 870 nm; cut ratio: 50%)



Filter eliminates emissions causing visual degradation while minimizing change in peak wavelength at which digital camcorder can react.

Time characteristics of noise signals

Bartley effect: Humans best perceive light signal when frequency of flashing light is around 10 Hz.



S.H. Bartley, “Some factors in brightness discrimination,” Psychological Review, vol. 46, pp. 337-358, 1939

Use ~10 Hz flashing in addition to noise signal (confirm effect through subjective evaluation)

Prototype system

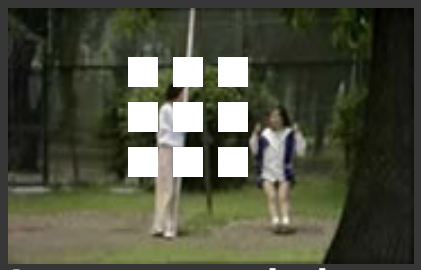
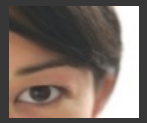


Image recorded with digital camcorder

Digital camcorder

Infrared light emission unit

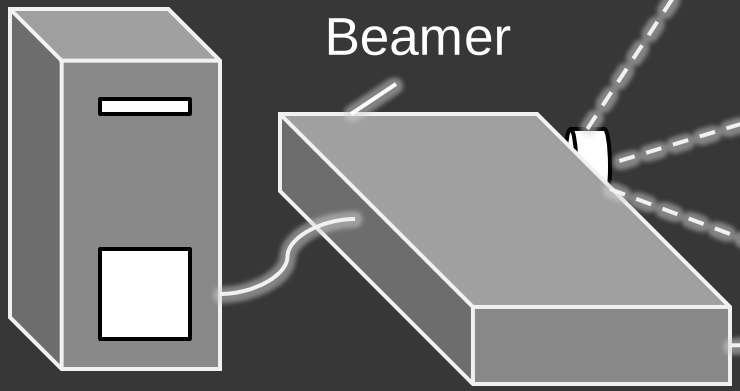
100-in. screen



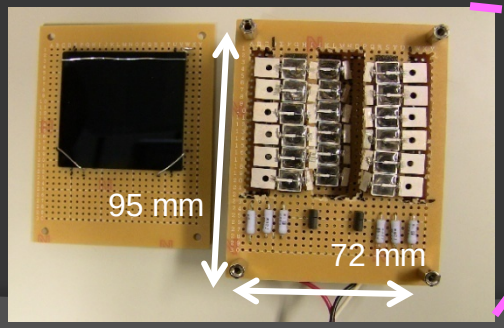
Human eye

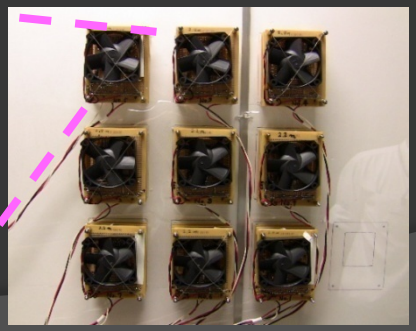
Image directly viewed by human eye

Beamer

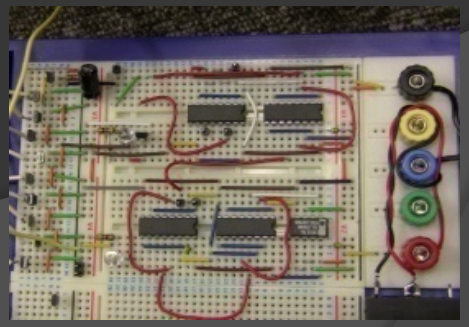


Infrared emission unit

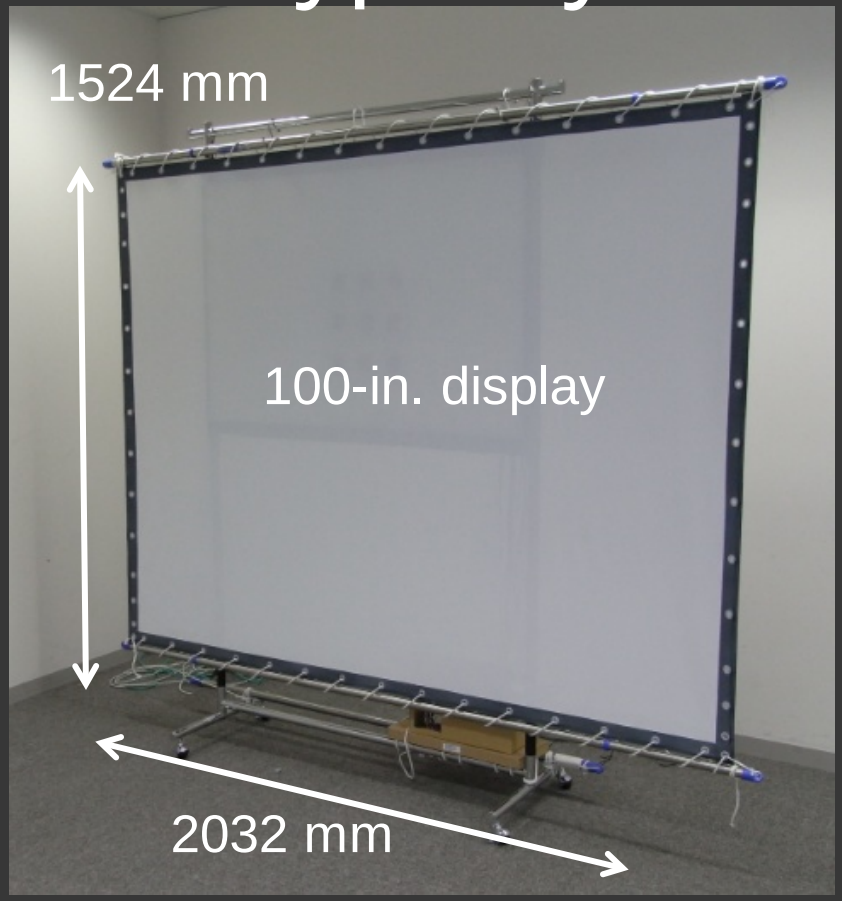




Flashing regulator circuit



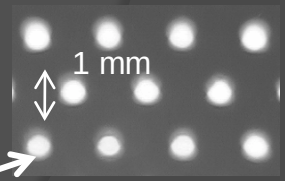
Prototype system



Front side

Back side

- **Many sound holes** in screen
- Place **infrared light units** behind screen
- **Infrared light passes through holes**
- No need to modify screen



Impact of re-recording prevention

- Internet news

September 24, 2009 | Company Profile | Japanese Site

The Mainichi Daily News

News

Movie theaters to use infra-red to foil pirates

Photo Journal

A new method for preventing pirates from recording films at movie theaters was unveiled by the National Institute of Informatics on Thursday.

The institute, in co-operation with Sharp, has developed a technique to render any recording unwatchable by flashing pulses of infra-red (IR) light from behind the cinema screen. The pulses pass through tiny holes in the screen originally designed to allow through sound, and cause interference to any video cameras held by members of the audience. The IR light, while invisible to human eyes, is also impossible to filter out without rendering the recording too blurry to watch. The team says best results are achieved at a speed of 10 pulses per second.

The technique was developed by a team led by Associate Professor Isao Echizen, who tested the effects of various wavelengths of invisible light on video cameras.

"It's a cheap, easy to install and effective method of prevention. widespread implementation in two to three years," said Echizen

Films screened at cinemas are already digitally watermarked to being copied digitally, but there has been no way of reliably stop recording films using video cameras.

The damage caused by bootleg film recordings is estimated at ar year, according to the American Film Institute, compounded by technology resulting in better quality recordings, and the spread equipped cell phones and Internet video sharing sites.

Click here for the

(Mainichi Japan) September 20, 2009

20th September 2009

Японские кинотеатры будут использовать новые методы для борьбы с пиратами

В разделе Наука, Технологии |

В четверг Государственный институт информатики представил новый метод по борьбе с пиратами, записывающими фильмы в кинотеатрах.

В сотрудничестве с компанией «Sharp» институт разработал технику, делающую запись из кинозала невозможной посредством импульсов инфракрасного света, мигающего из-за киноэкрана. Импульсы будут проходить через крошечные отверстия в экране, которые

ить помехи на любых
ный свет незаметен для
ся без чрезмерного

ости 10 импульсов в секунду.

м адъюнкт-профессора Исао
имого света различной длины

лактики. Мы рассматриваем

ыми «водяными знаками» для
х пор не было надёжного
видеокамер. Ущерб,
ериканского института
ляется современным
повышения качества записи.
деокамерами, и веб-сайты,

新华网 WWW.NEWS.CN

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您的位置：新华网主页 － 新华国际

日本开发出防止影院偷拍的装置

2009年09月19日 10:37:42 来源：新华网

【字号 大 中 小】 【留言】 【打印】 【关闭】 【Email推荐： 提交 】

新华网东京９月１９日电（记者刘赞）在电影院中偷拍电影是制作盗版电影方式之一。针对这种行为，日本研究机构最近开发出一种装置，可以使在电影院中偷拍的翻拍片报废。

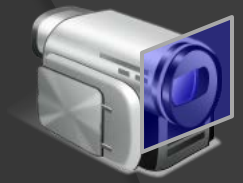
这种装置是日本国立信息学研究所和夏普公司共同开发的。该装置安装在电影屏幕的背面，它能发出人眼不可见的红外线，透过屏幕上为增强影院音效而开的无数细小孔洞射向观众。由于人眼看不到红外线，因此这不会对现场观众观赏影片产生影响。但如果有人用摄像机非法偷拍，由于摄像机的感光元件可以拍下红外线，因此偷拍的影片上会出现红外线的干扰亮点，使之无法用于制作盗版电影。

这种装置使用的红外线发射器与家用电器遥控器上的红外线发光二极管相同，安全性高而成本低，易于普及。红外线的发射采用１０赫兹的频闪方式，据称这一频率干扰效果最强。如果偷拍者在摄像机上加装红外线滤镜进行拍摄，将会导致偷拍的影片本身也不清晰。

日本国立信息学研究所副教授越前功表示，他们希望能在３年内实现这一装置的实用化，并向国内外电影院推广。

据美国电影协会估算，以偷拍方式制作的盗版电影每年给电影业界带来的损失高达３０亿美元。

Countermeasure against attacker using IR cut filter

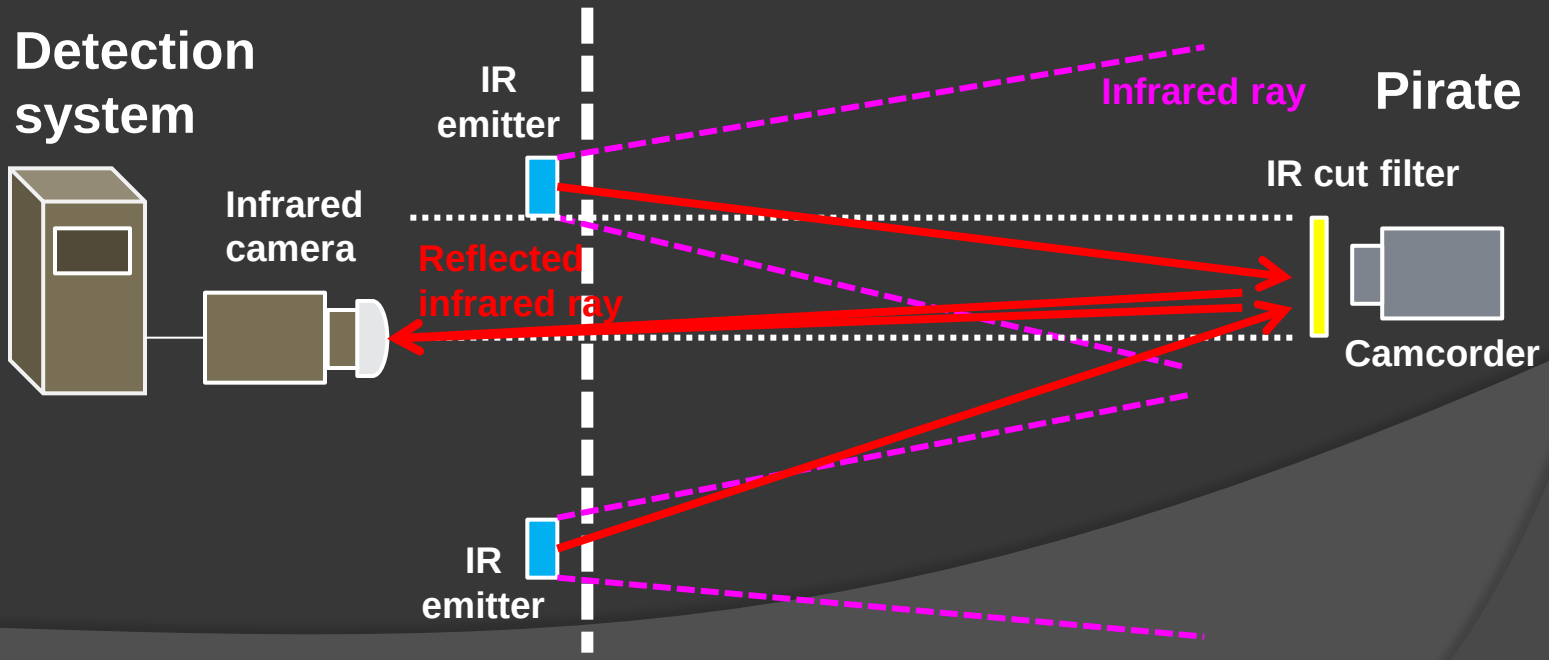


Attack using infrared cut filter

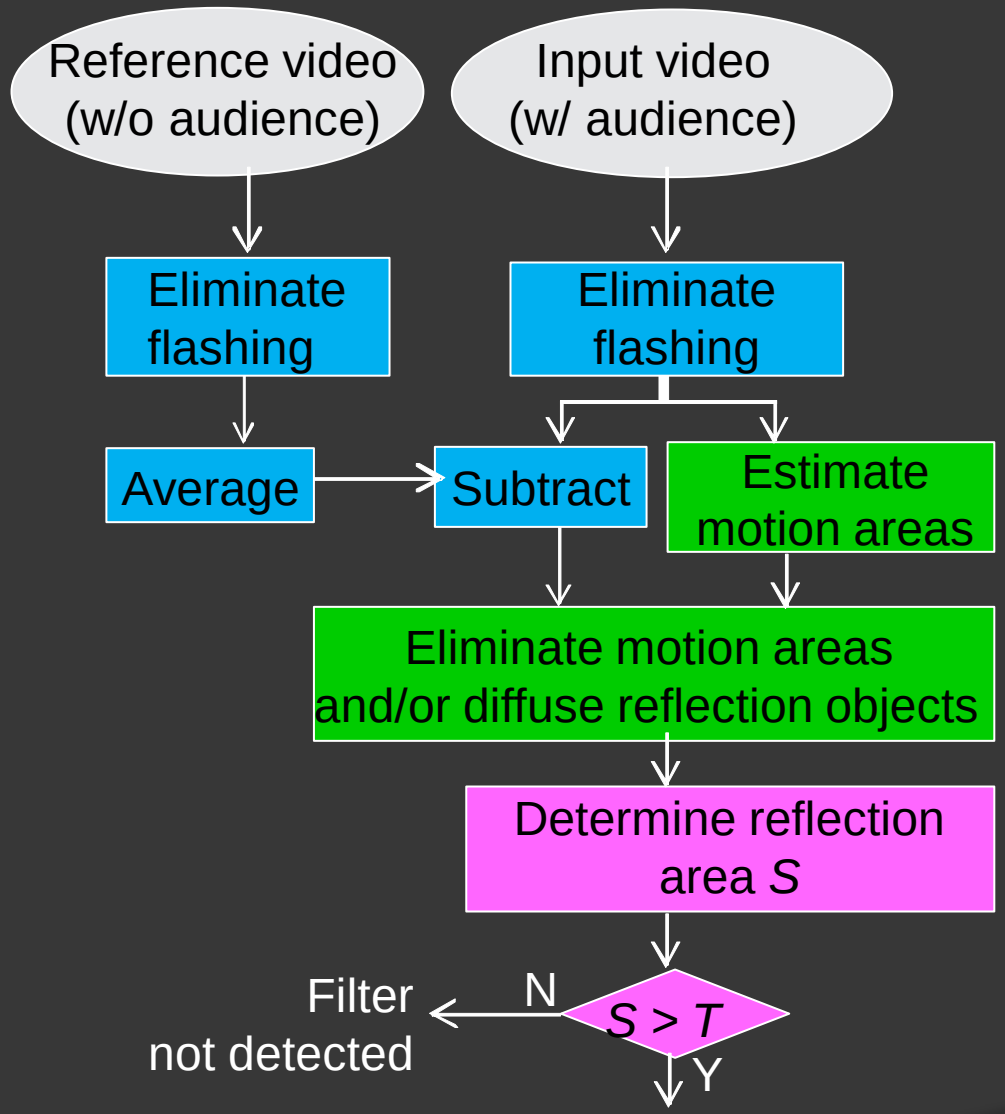
- Attaching IR cut filter to some camcorders eliminates infrared noise.

Countermeasure based on infrared specular reflection of cut filter:

Detect infrared rays reflected by filter using properties of infrared specular reflection of cut filter -> detect reshooting with filter.



Filter detection algorithm



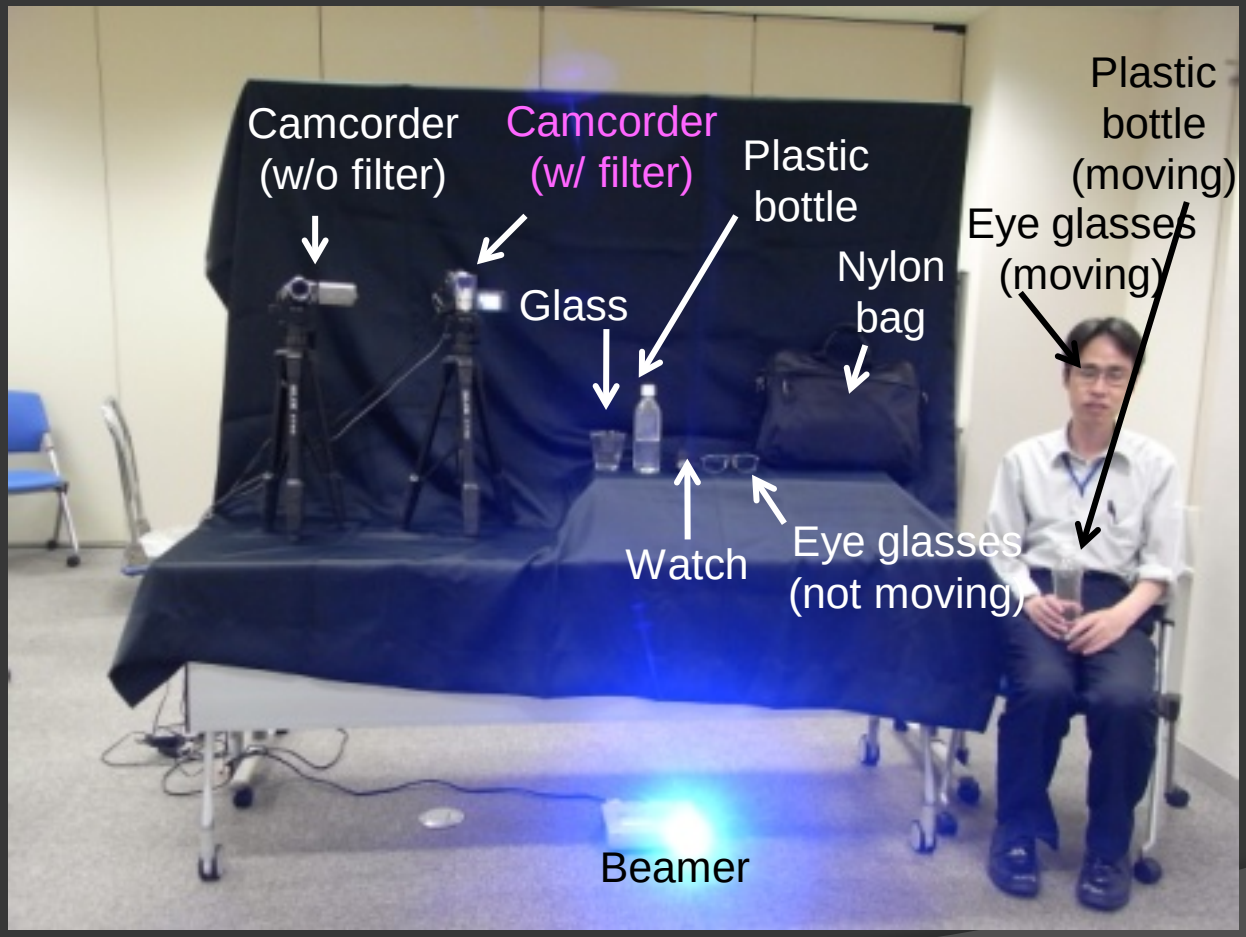
Subtraction process
Eliminate reflections off objects already in room.

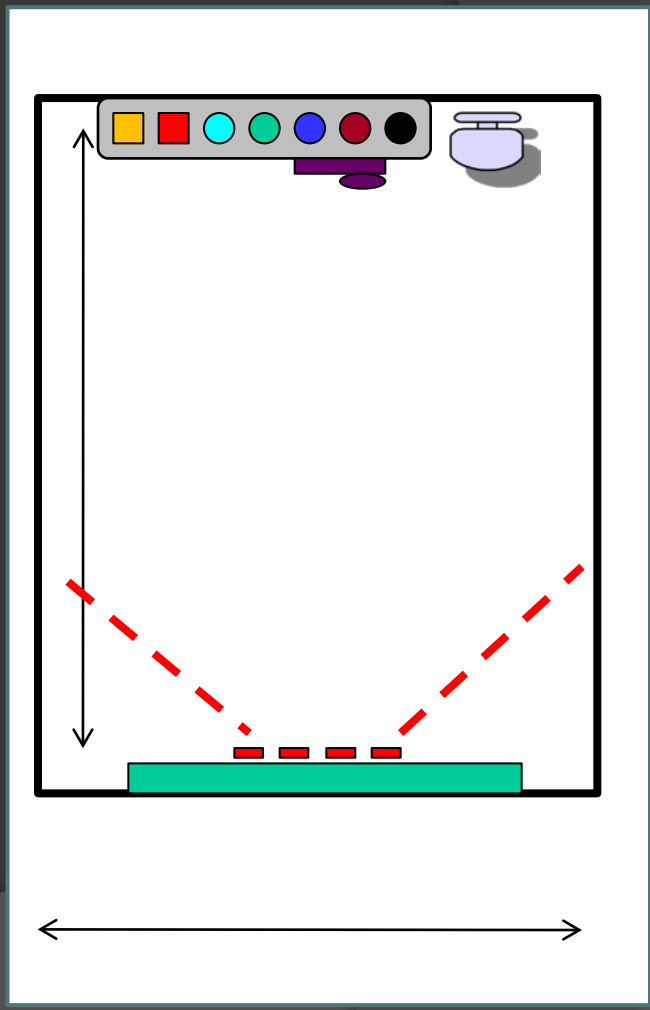
Motion detection process
Eliminate moving and/or diffuse reflection objects.

Filtering process
Calculate area of each reflection area and compare with threshold.

System evaluation

Ability of system to detect IR-cut filter was evaluated using various reflective objects typically found in a movie theater.





Disclosure of confidential/personal information through displays

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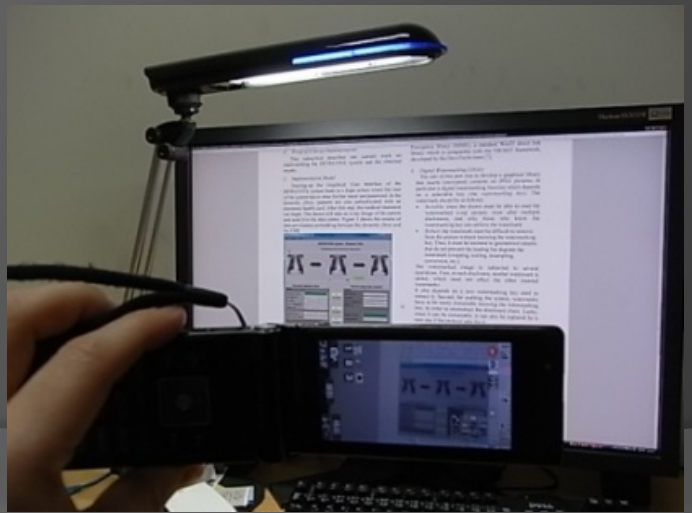
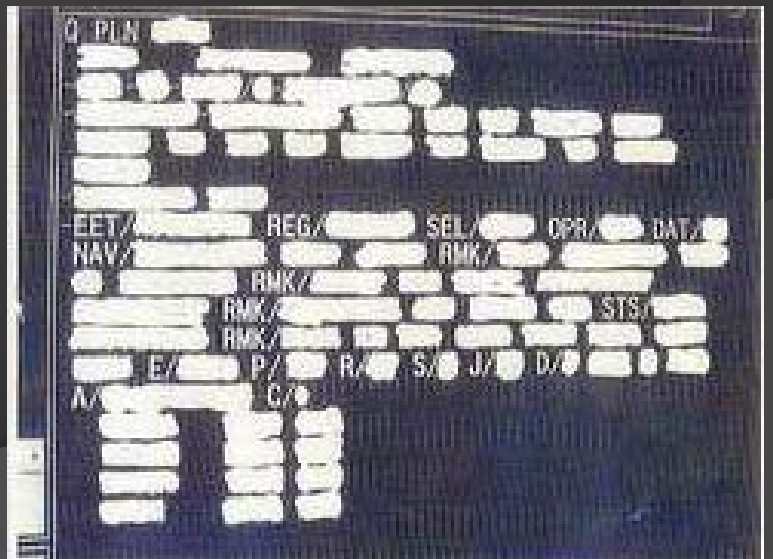


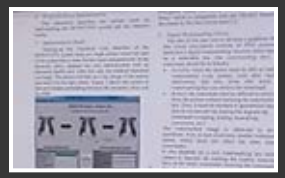


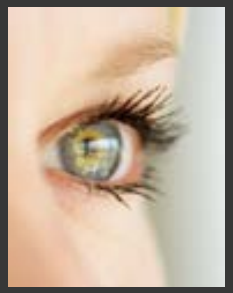
Requirements for preventing illegal copying

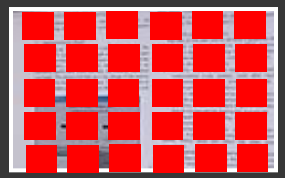
	On *screen*	On *display*
Target	Films	Confidential info. (military/government secrecy), personal info.
Purpose	Copyright protection	Protecting info. leakage
Installation	On back side of screen	Incorporated into display
Noise signal: spatial properties	Superposed on central part of image (prevent copyright infringement)	Superposed on whole image (prevent information leakage)
temporal properties	Use of Bartley effect (flashing at ~10 Hz)	Not applicable (each picture frame should be equally degraded)
Implementation	Easily implemented (by vendor)	

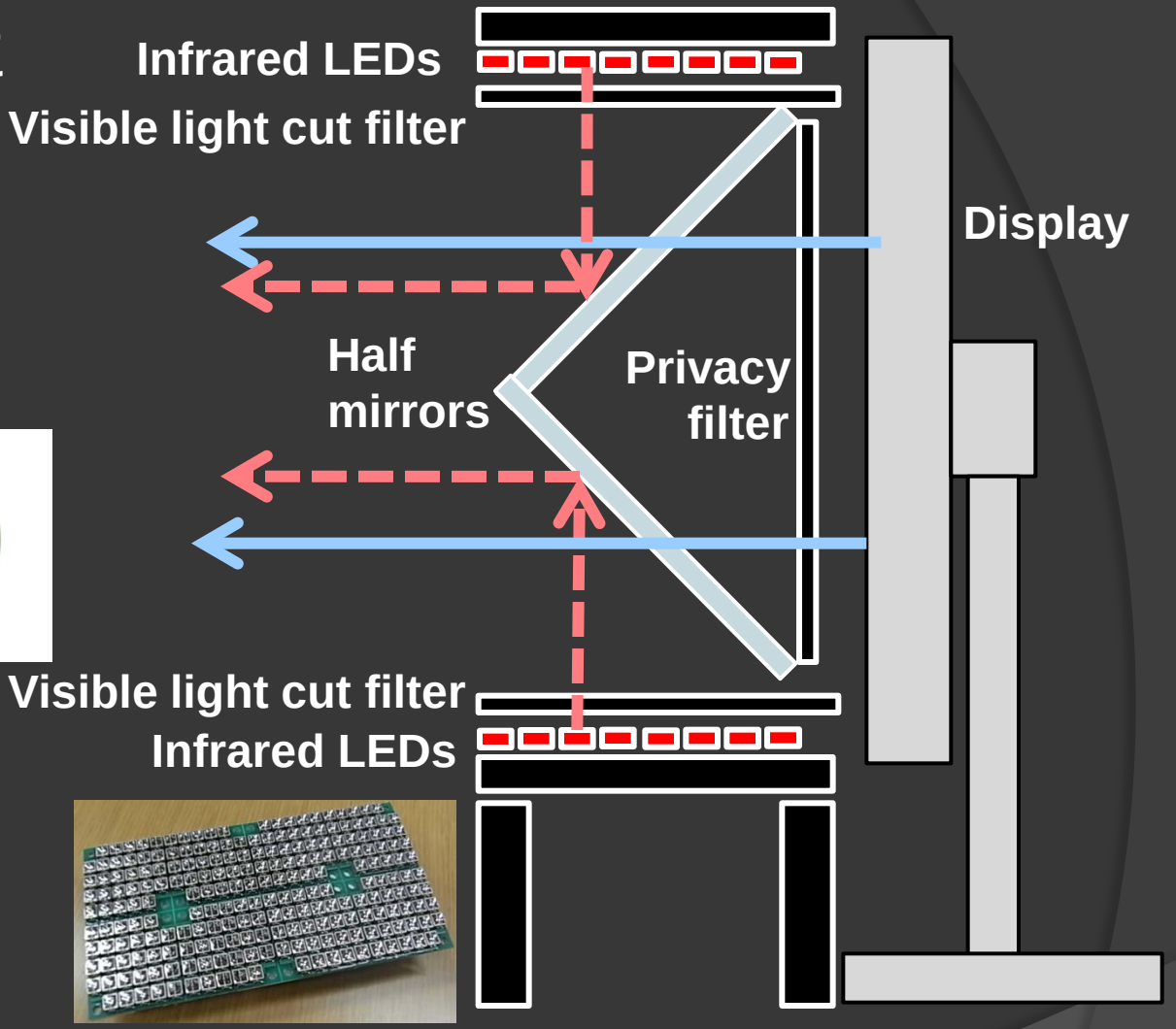
We propose using half mirrors and IR LEDs.

Anti-copying unit









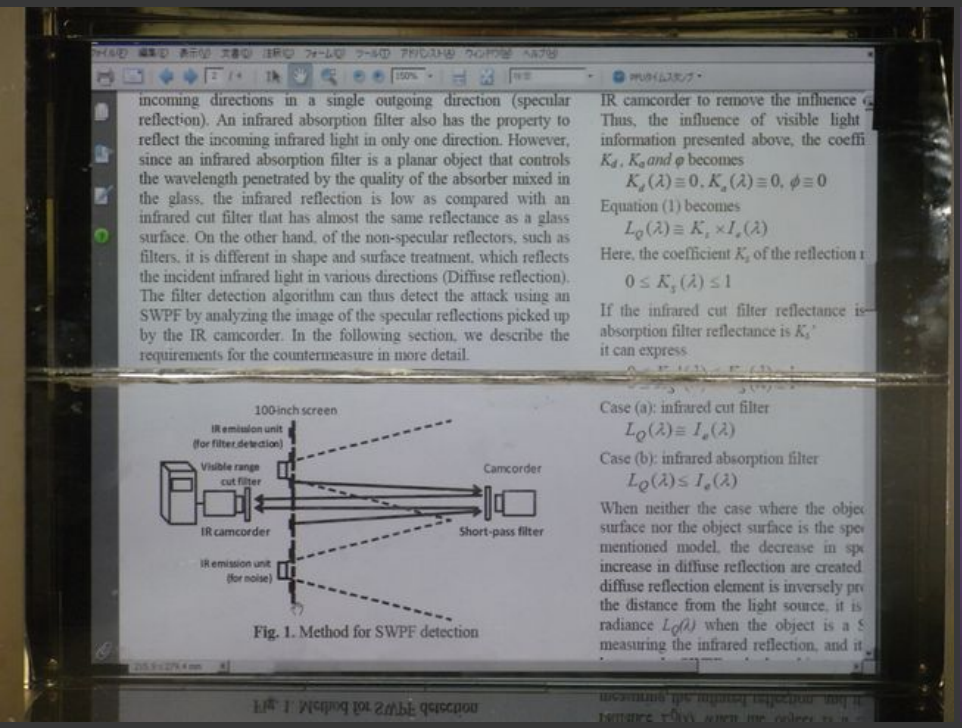
- Prevents unauthorized copying of information shown on display
- Placed in front of existing display
- No impact on normal viewing of display

Anti-copying unit

Front

Back
(Mounted in front of 17-in. LCD)

Example images (displayed content)



Without IR emission

With IR emission

Unauthorized copying of actual objects

- Not only for information shown on displays
  - Facilities inside factories → confidential information leakage
    - Prevent unauthorized copying with anti-piracy seal



  - Printed matter (confidential docs, exams, books, etc.)
    → information leakage, copyright infringement
  - People (or their belongings) → invasion of privacy

Can be used to prevent unauthorized copying of actual objects

Example images (actual object)

Without IR emission

With IR emission

Countermeasure against IR cut filter

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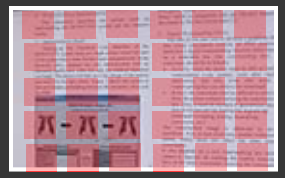


Infrared-cut filter

Half mirror

Privacy filter

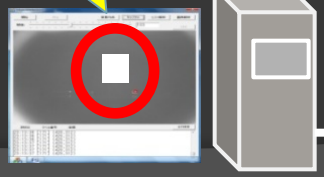
Display

Visible light cut filter

Filter detected!

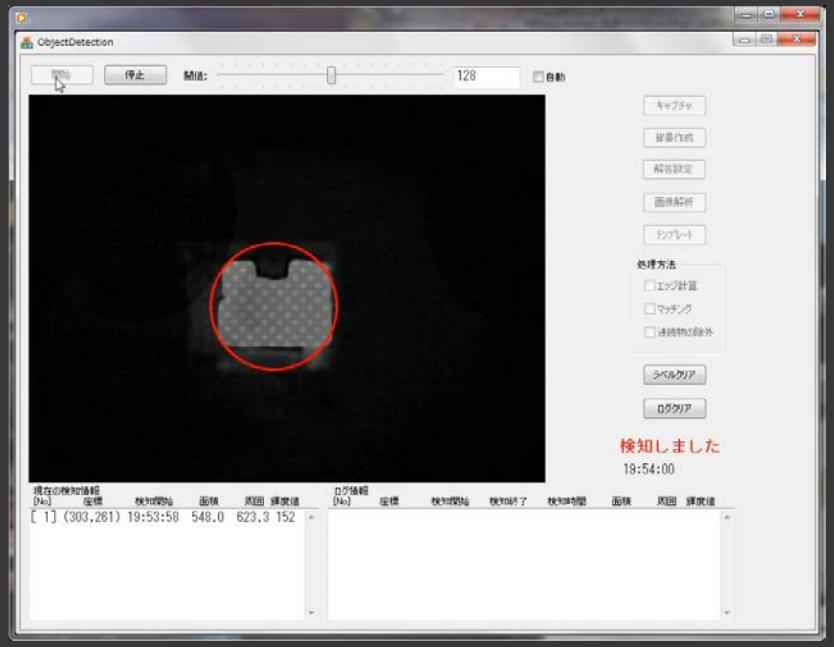
Infrared LEDs

Filter detection algorithm

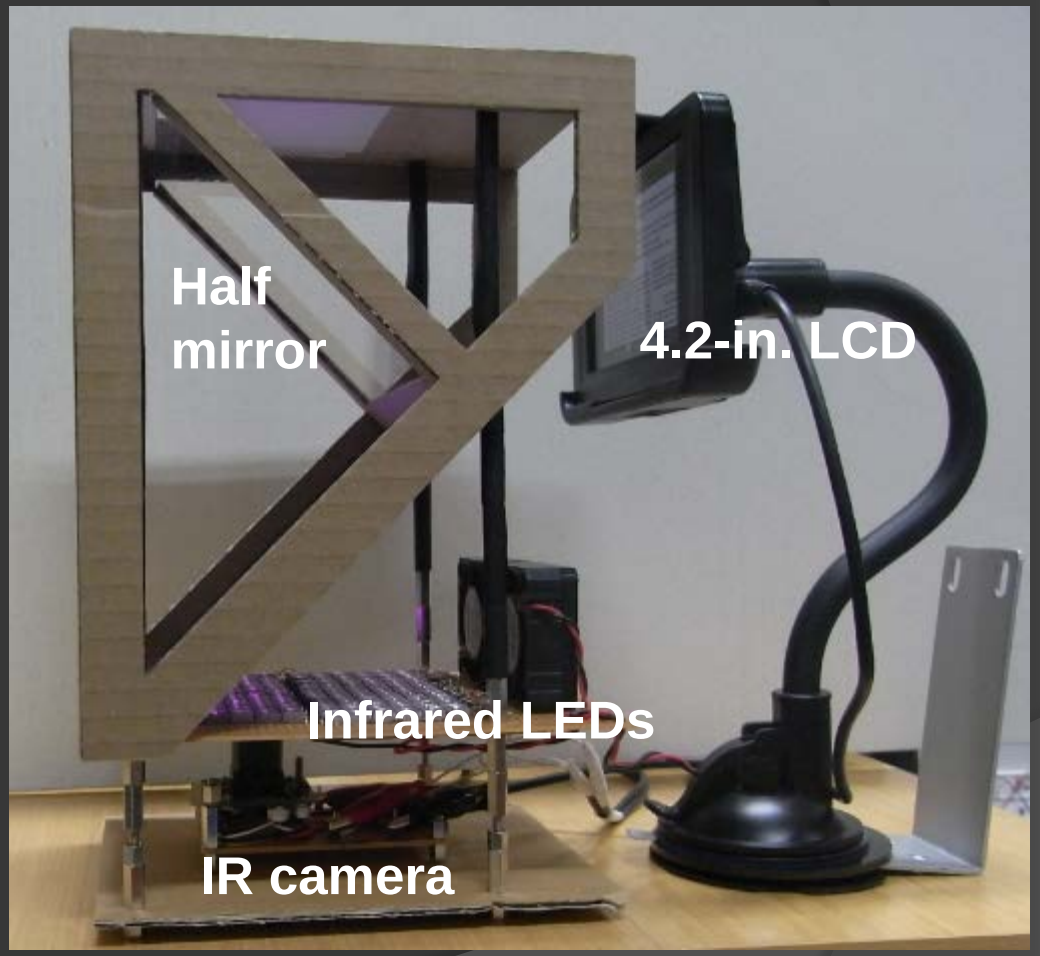


IR cam

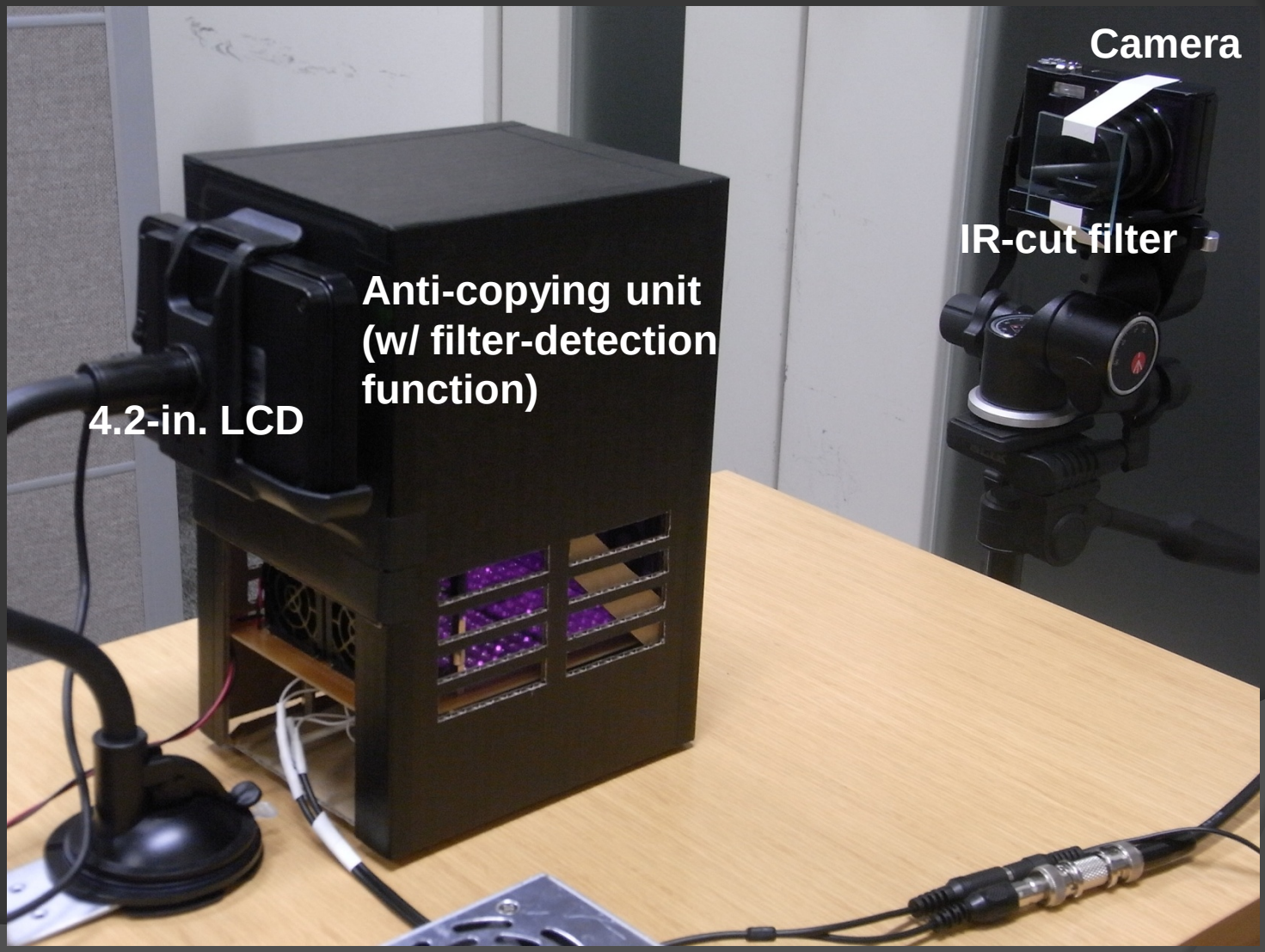
Evaluation using functional prototype



Specular IR reflection from IR-cut filter can be detected.

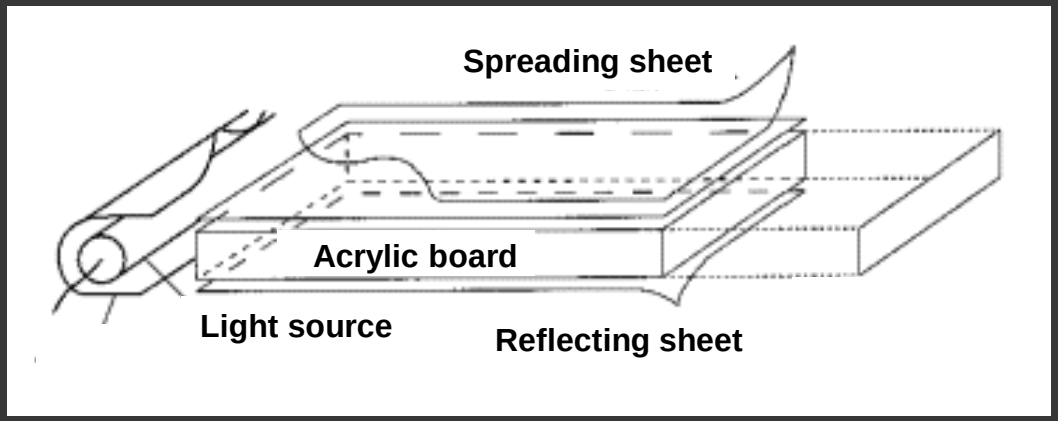


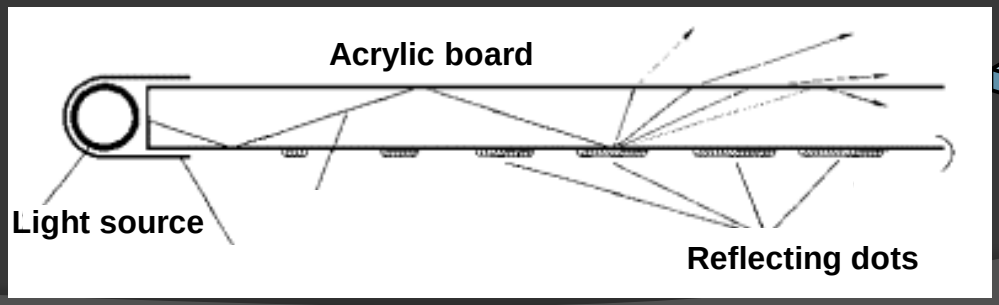
Anti-copying unit



Making the anti-copying unit thinner

Anti-copying panel based on backlight LCD technique (light guide plate with IR source light) can be used for various applications.

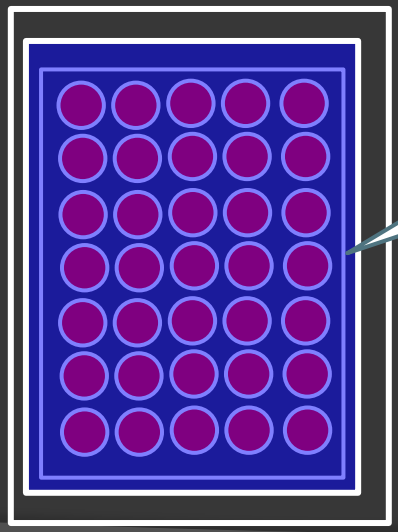




Configuration of light guide plate (backlight LCD)

Application of transparent organic light emitting diodes to display

- Developed by TDK (October 2010)
- Transparent phone (Lenovo S800) Released, June 2011



IR emission panel can easily be implemented

Transparent phone w/ anti-copying unit

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[2] T. Yamada, S. Gohshi and I. Echizen, "IR Hiding: Method to Prevent Re-shooting Videos based on Sensory Perceptions of Devices," in Proceedings of the 9th International Workshop on Digital Watermarking (IWDW 2010), LNCS, pp. 296–309, (October. 2010).

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[6] I. Echizen, T. Yamada and S. Gohshi, "IR Hiding: Method for preventing illegal recording of videos based on differences in sensory perception between humans and devices," to be published in LNCS Transactions on Data Hiding and Multimedia Security, vol. 6, 18 pages, to appear, (2012).