大学共同利用機関法人 情報・システム研究機構
国立情報学研究所
National Institute of Informatics

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RE-SHOOTING PREVENTION BASED ON DIFFERENCE BETWEEN SENSORY PERCEPTIONS OF HUMANS AND DEVICES

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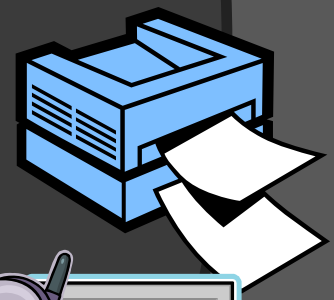
Background: problems with content distribution

- Security countermeasures: independently treated in cyber/physical world
  - Content protection: cyber world
  - Property management: physical world

- Flaws in countermeasures on border between cyber and physical world
  - Cannot stop malicious behavior by legal person
  - Analog hole problem
    - Information leakage of printed documents through illegal copying
    - Re-shooting PC monitors using cell-phone cameras
      -> uploading shot content



- Our aim: establish security countermeasures border between cyber and physical world

Analog-hole problem

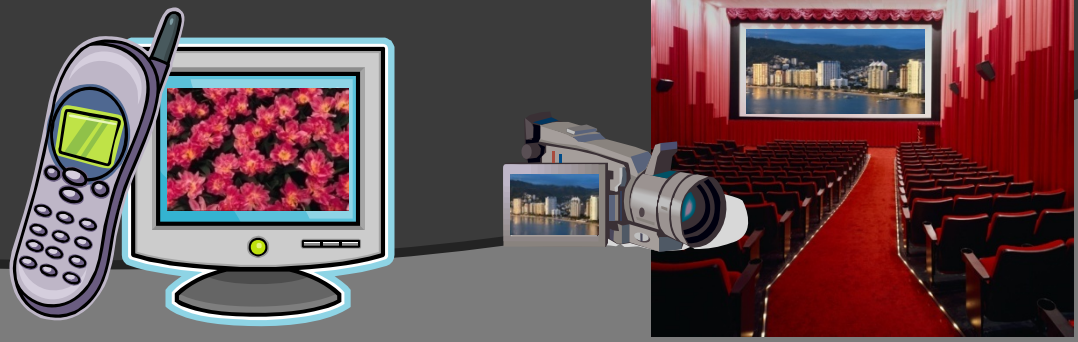
Conventional problem

- Insufficient security of analog-output terminals of digital equipment
- Resolution by replacement with digital terminals

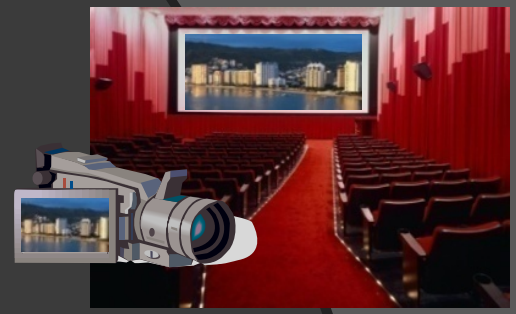
Rise of new problem exploiting monitors and screens

- Availability trend of increasingly high-quality monitors and cameras makes it easy to reshoot presented content

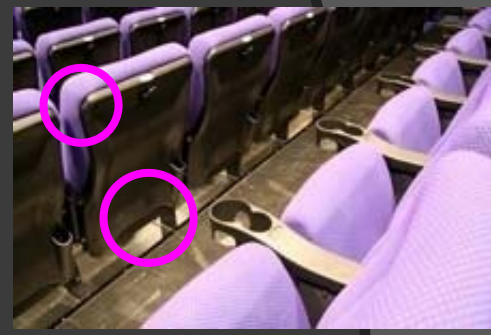
  -> Distribution of illegally re-shot content
  - Ex. re-shoot PC monitors with cell-phone cameras -> upload shot content
  - Ex. re-shoot theater screens -> sell pirate DVDs
    - Loss of $3 billion USD per year (survey by Motion Picture Association of America)



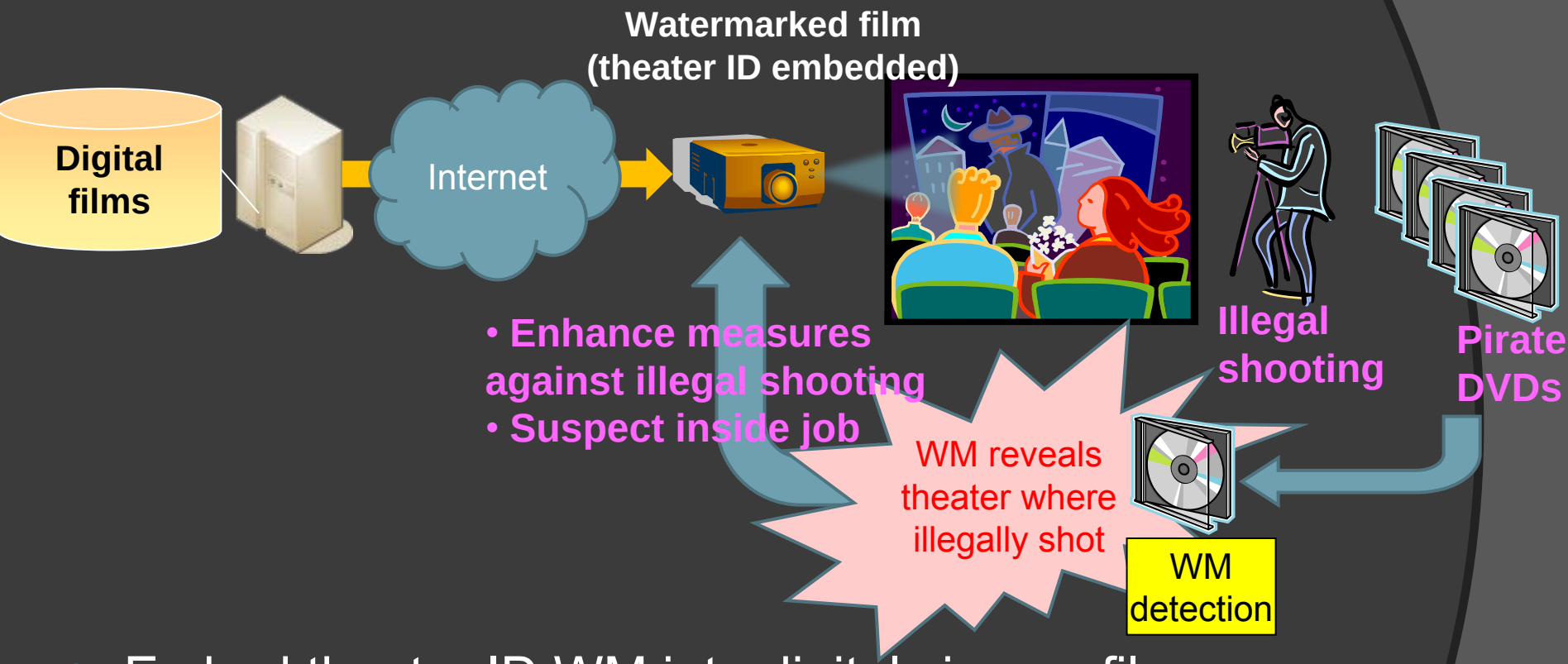
Pirating at movie theaters



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



Conventional measures against re-shooting: use of digital watermarks



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

But: no control of re-shooting

Re-shooting countermeasures

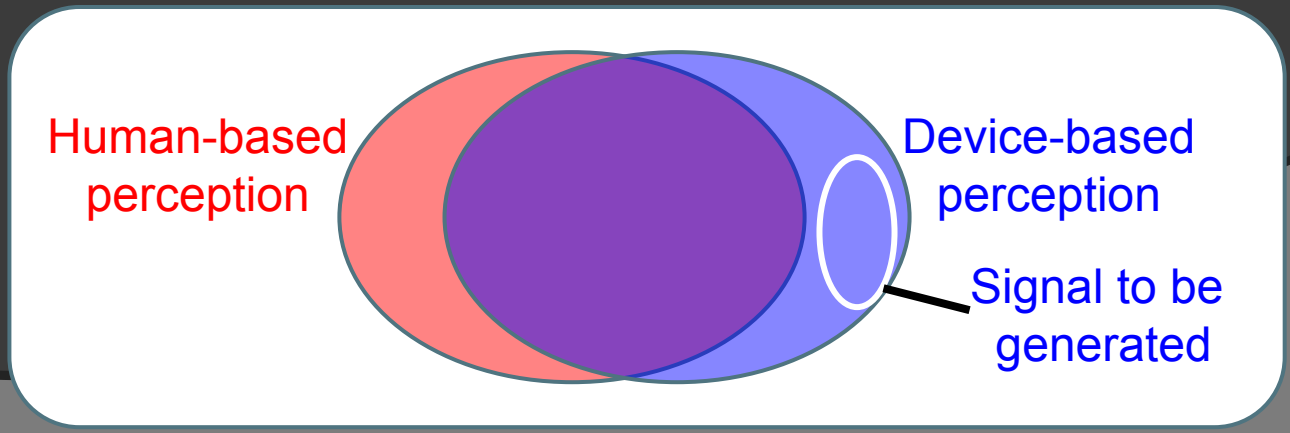
- Objective and approach -

Objective:

- Establish countermeasures to stop re-shooting
  - Addition of new functions in existing user-side devices is unnecessary (ex. cam)

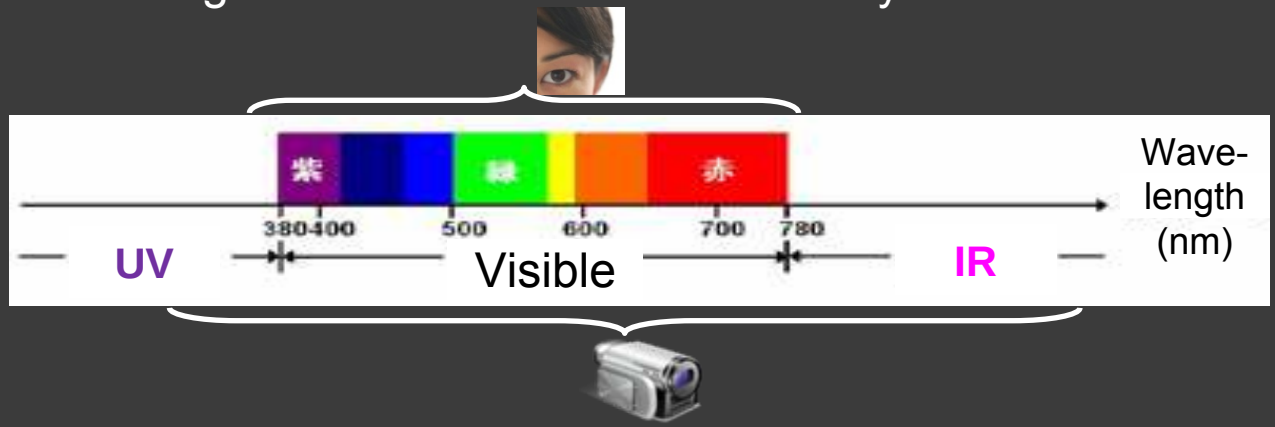
Approach:

- 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: 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 should 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 equipment

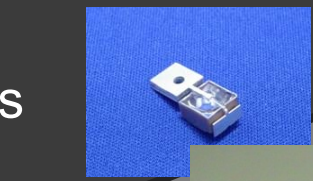
IR light emitters: lasers, diodes, xenon/halogen lamps

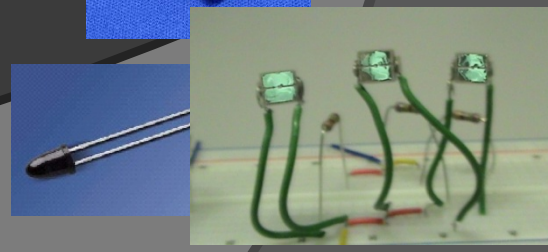
-Safety: not harmful to humans

-Radiation angle: effective at any display angle

-Cost effective, easily replaced

Use of near-infrared LEDs



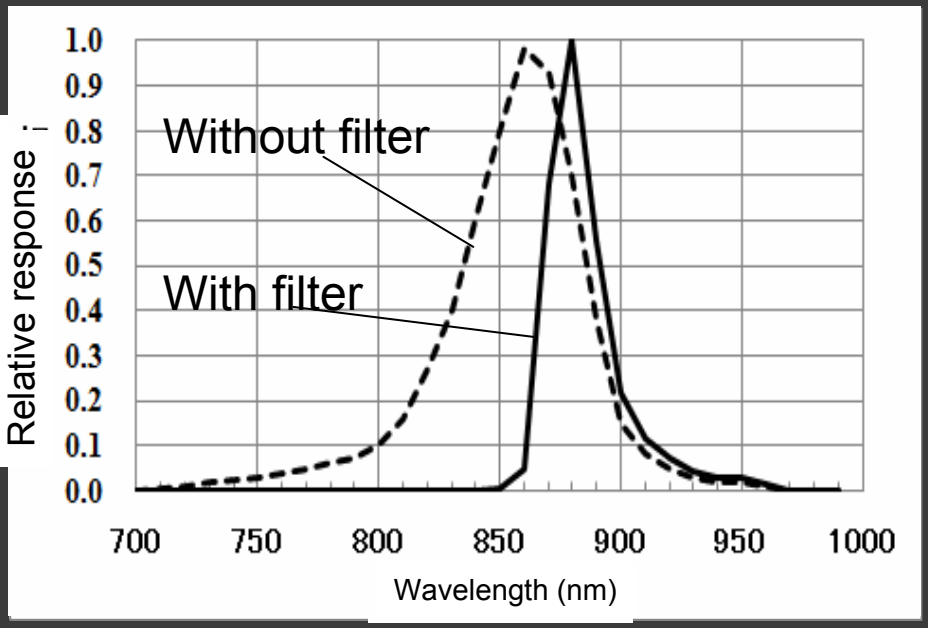


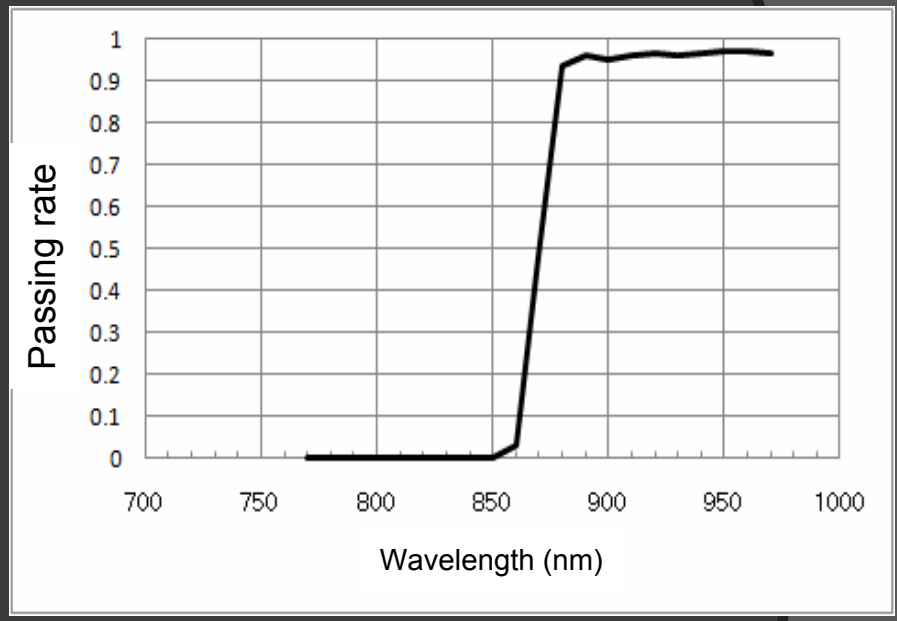
Near-infrared LEDs

Measures against visual degradation: Use of short-wavelength cut filter

Near-infrared LED
(peak wavelength: 870 nm)

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





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

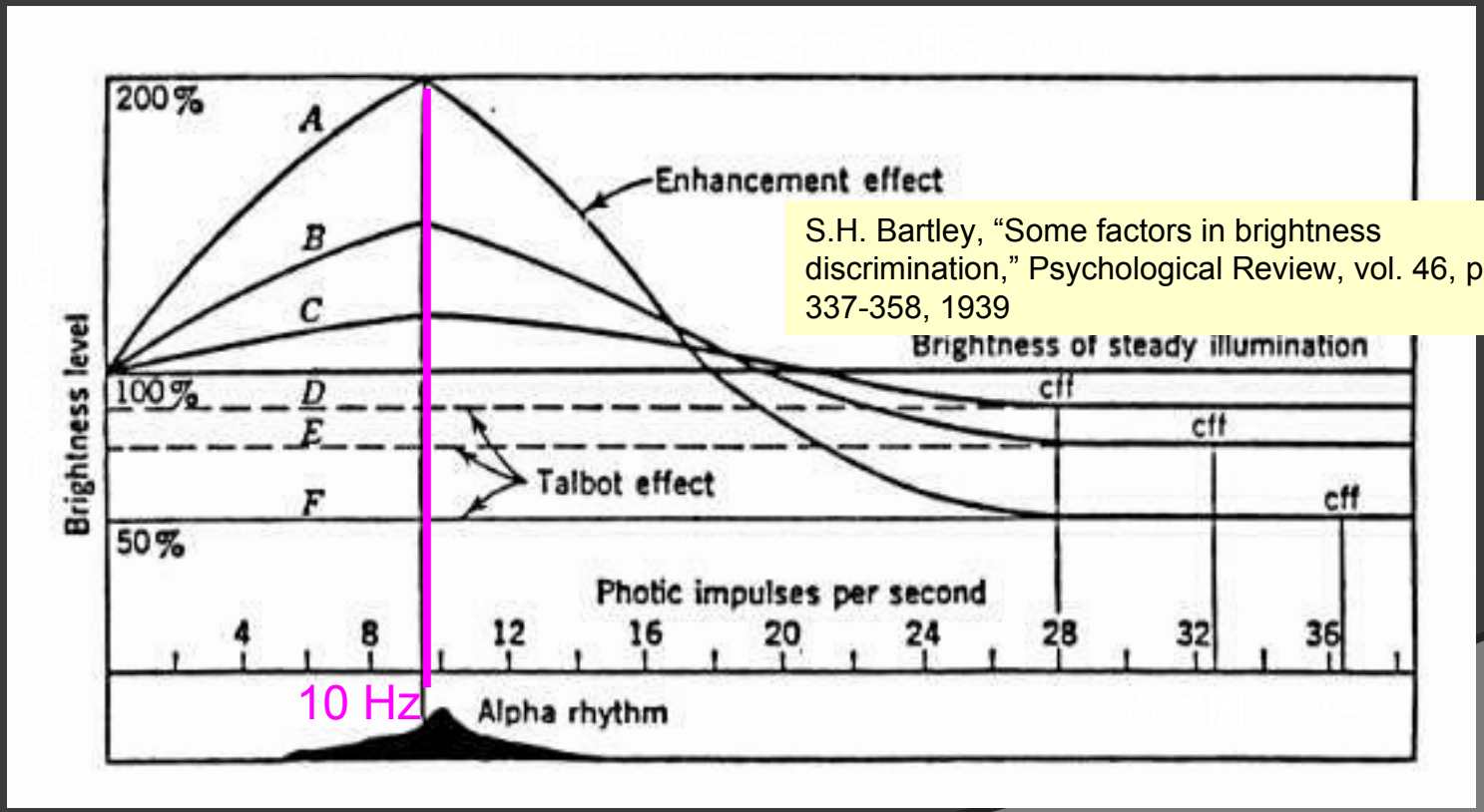
Time characteristic of noise signals

Bartley effect:

Humans can best perceive light signal when frequency of flashing light is around 10 Hz.

Talbot's law

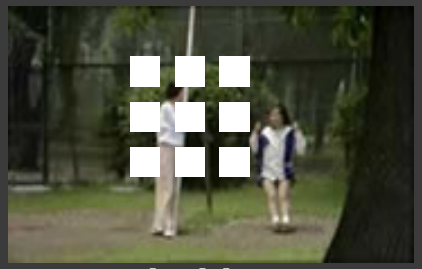
Humans can perceive continuous light with average flashing light intensity when frequency of flashing light is fast.



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

Use flashing with frequency of around 10 Hz in addition to noise signal (confirm effect through subjective evaluations)

Prototype system

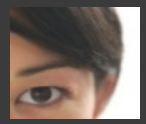


Recorded image by digital camcorder

Digital camcorder

Infrared light emission unit

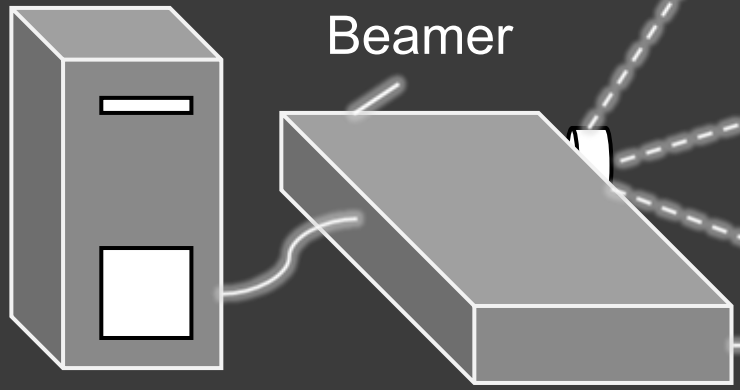
100-inch screen



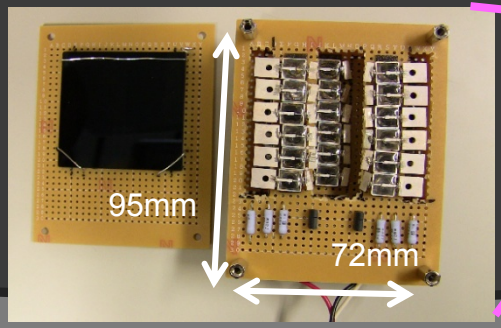
Human eye

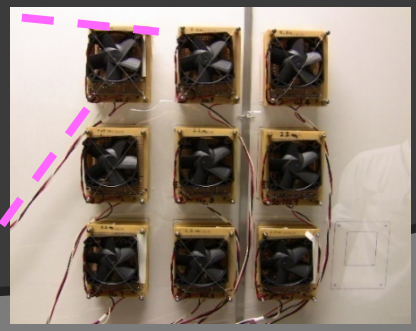
Direct viewed Image by human-eye

Beamer

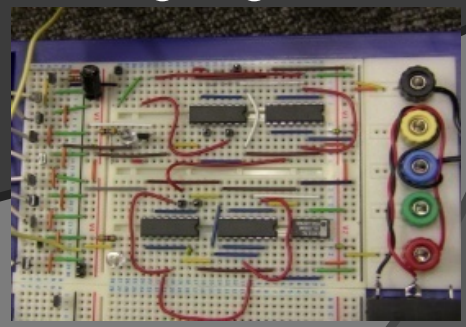


Infrared emission unit

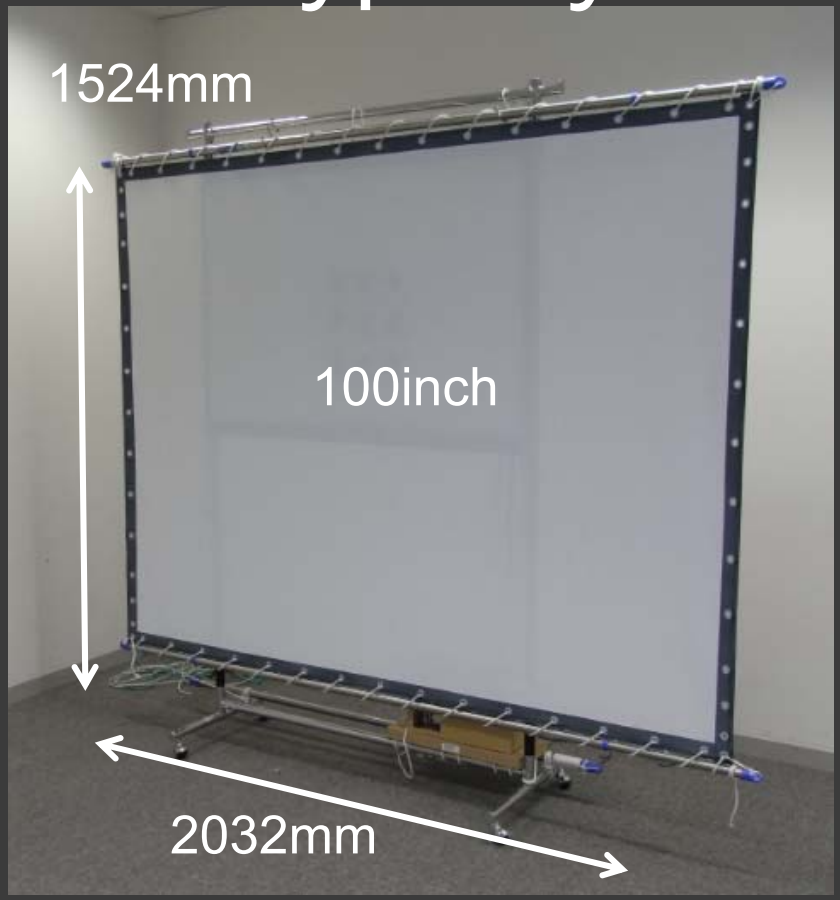




Flashing regulator circuit



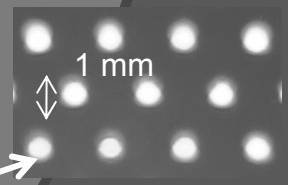
Prototype system



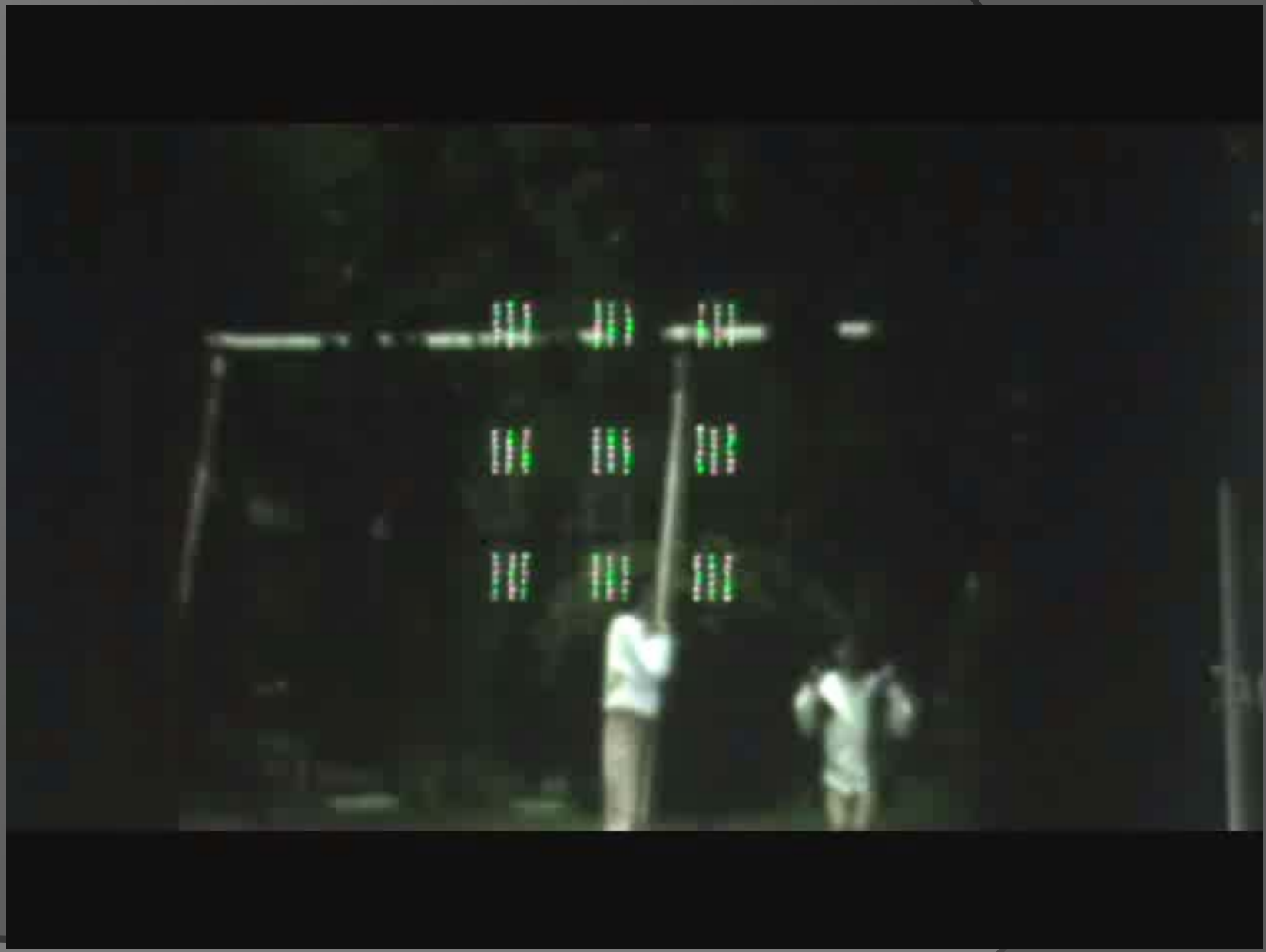
Front side

Back side

- **Movie screen**: many sound holes to combine sound and video
- **Unit of infrared light emission**: place on back side of screen
- **Infrared light**: gets through holes
- **Advantage**: No need to modify screen



Demo: shot video

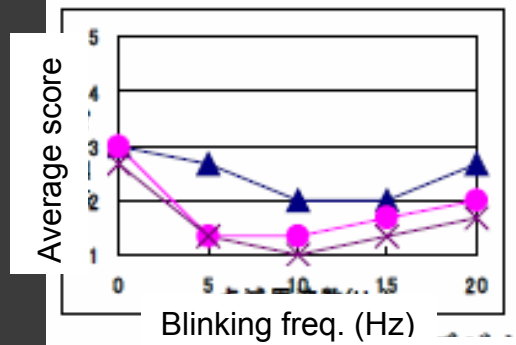


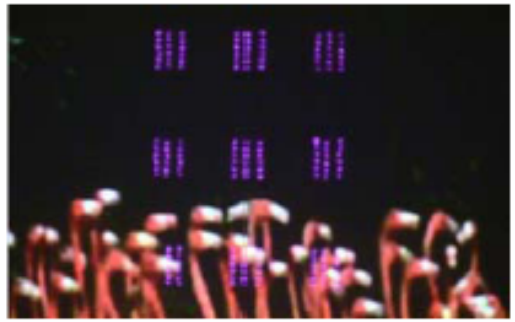
Raise disturbance level by exploiting Bartley effect

- Bartley effect
  - Approx. 10 Hz of flickering light appears brighter than steady light of same average luminance
- Subjective evaluation (ITU-R BT. 500-7)
  - Level of disturbance of shot video according to 5-point rating scale (10 evaluators)

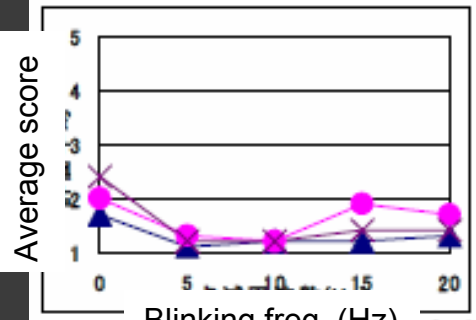
Disturbance	Scores
Imperceptible	5
Perceptible but not annoying	4
Slightly annoying	3
Annoying	2
Very annoying	1

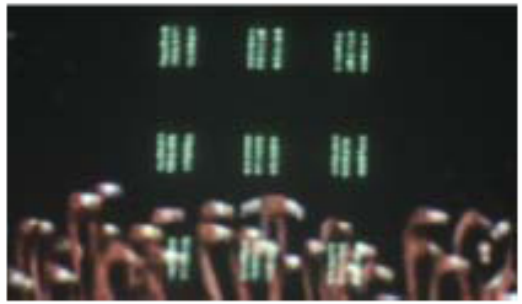
  - Results: raise disturbance level to around 10 Hz



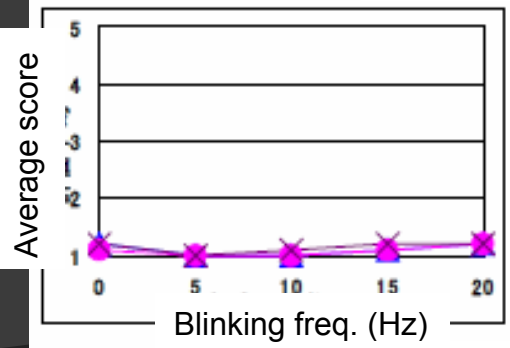


Digital cam (CMOS)





Digital cam (CCD)



Camera cell-phone (CMOS)

Impact of re-shooting prevention

- News release
  - Re-shooting prevention based on difference between sensory perceptions of humans and devices; National Institute of Informatics, 09/17/2009

- TV program
  - NHK (Public broadcaster in Japan)
    - Evening news program (09/17/2009)
    - Morning news program, live broadcast (09/28/2009)
    - News program noon, dope story (10/01/2009)
    - NHK world, Techno-Frontiers: Fighting Film Piracy (11/04/2009, 12/29/2009)
  - TV Tokyo (Key commercial TV station)
    - World Business Satellite (09/29/2009)

Impact of re-shooting prevention

- Internet news

September 24, 2009 | Company Profile | Japanese Site

The Mainichi Daily News

News

Movie theaters to use infra-red to foil pirates

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

Photo Journal

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 кинозкрана. Импульсы будут проходить через крошечные отверстия в экране, которые

ть 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.
еокамерами, и веб-сайты,

新华网
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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。

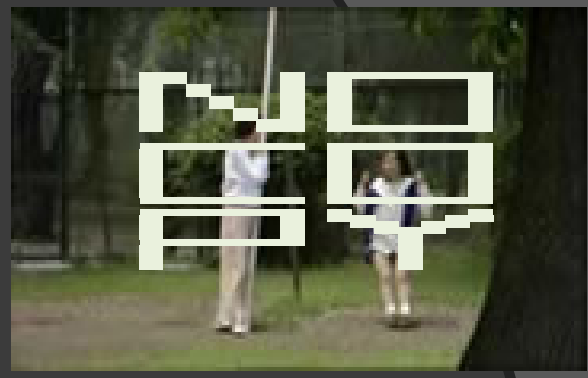
据美国电影协会估算，以偷拍方式制作的盗版电影每年给电影业界带来的损失高达３０亿美元。

NHK world (December 29th, 2009)

Conclusion

- Pirates re-shooting at movie theaters
  - Cause serious damage to movie companies; Re-shooting prevention measures are needed.
- Previous countermeasures
  - Laws to prevent illegal shooting of movies in theaters (in Japan)
  - Technical measures: use of digital watermarking
  - No direct control of re-shooting
- Re-shooting prevention based on difference between sensory perceptions of humans and devices
  - Corrupt content by adding near-infrared signals using CCD or CMOS devices during recording.
  - No new functions added to camcorders.
  - Increase effect of noise by exploiting Bartley effect
- Implementation on 100-inch cinema screen
  - No need to modify screen
  - Subjective evaluation proves effectiveness.

Future work



- Increase noise effect
  - Alignment of noise signals
  - Use sophisticated flashing patterns

- Apply to various displays including LCD and LED monitors

- Countermeasures against infrared-cut filter