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Automated Lecture Recording System with AVCHD Camcorder and Microserver

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Lecture recording

- lecture videos can help students
  - assist slow learners
  - allow reviewing in case of absence

- lecture videos are becoming popular:
  - MIT's OpenCourseWare
  - iTunes U, You Tube,etc

MITOPENCOURSEWARE
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

- But, lecture recording takes cost.
  - Major universities with enough resources are OK.
  - How about other universities ?

What is a cost effective, laborsaving solution ?

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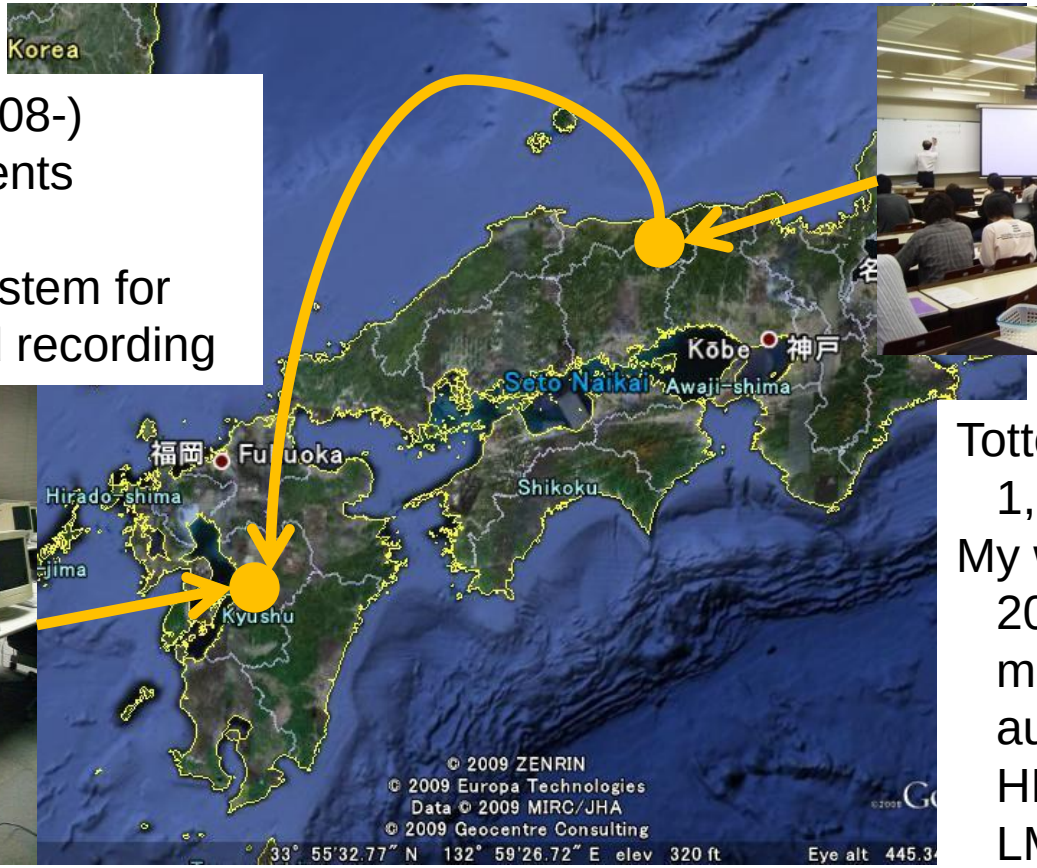
My experience in lecture recording

- 2004- (Tottori), 2008-(Kumamoto)

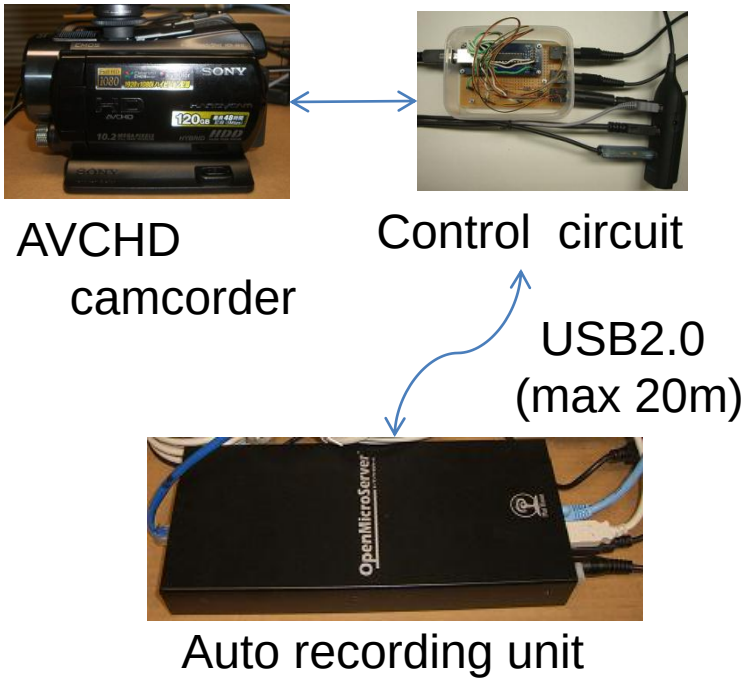
Kumamoto(2008-)
11,000 students
My work:
prototype system for
unmanned recording



Tottori(2004-)
1,000 students
My work:
20-25recording /week
manual recording
auto post-processing
HDD camcorder
LMS integration

Our solution

- Cost-effective recording unit
  - High-definition camcorder + Microserver
  - Use only consumer product



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Problems in traditional lecture recording

- Human operator

  labor intensive solution

  - dedicated staff takes cost
  - student staff needs training and management

    →prohibitive operational costs

- Robotic tripod cam

  capital/hardware intensive solution

  - expensive
  - not easily deployable

  →limited recordable rooms

Key ideas

- We don’t have to operate camera during lecture.
  - Stationary camera is enough *if it is high-definition*.
  - The cost of consumer HD camcorder is decreasing.
- Ideas for *cost-effective large-scale* recording
  1. HD recording and *virtual camerawork*
     - We can generate camerawork in post-processing.
  2. Automated lecture recording in HD
     - HD video capture without capture board
     - schedule management by iCalendar

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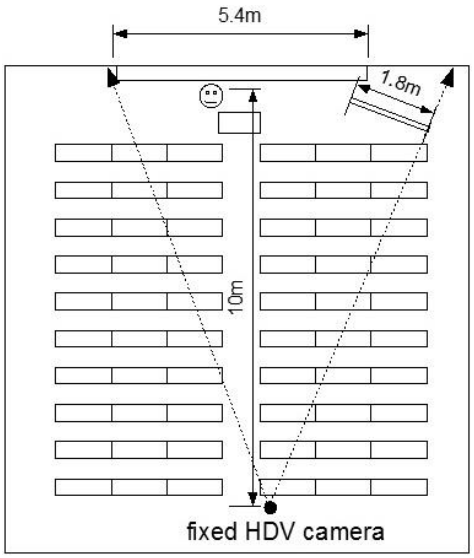
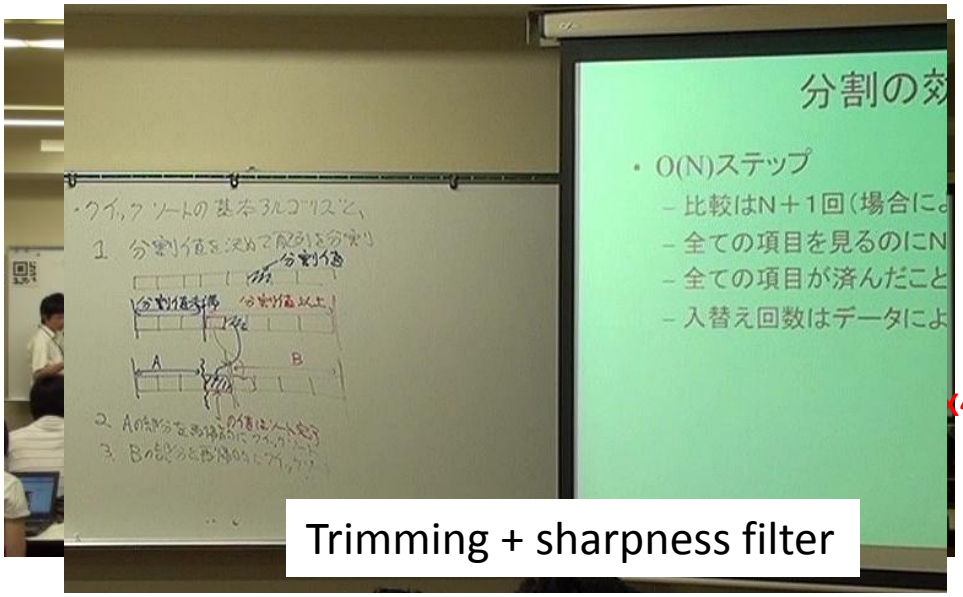
Recording with an HDV cam

- Recording with an HDV(high-definition video) cam
- We can record the entire room with a fixed angle.
  - the resolution of image is enough to read letters





1920x1080

480

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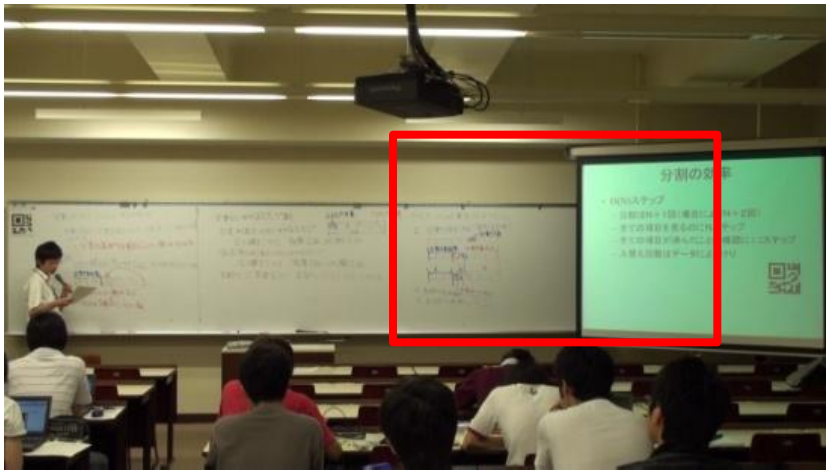
Virtual camerawork

- Pseudo camera motion by moving trimming window
  - originally studied to analyze professional camerawork
- HD video is useless if displayed on a small display



1920x1080

720x480

  - We use virtual camerawork to produce a standard resolution video that contains regions of interest.

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Questions

- Can we really implement HD recording system cost-effectively?
- How do we capture HD video automatically ?
  - Do we need a high-end desktop PC ?
- How do we control HD camcorder ?
  - Do we need a professional/special device ?
- How do we process HD video automatically ?
  - Do we need a proprietary software ?

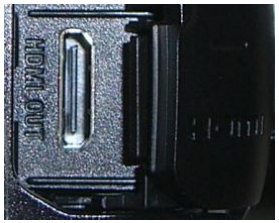
Topics

- System design
- Automated recording
- Schedule management
- Video processing
- System deployment

How to capture HD video cost-effectively

- Capture HDMI signal (common solution)
  - We need an HDMI capture board
  - The capture is done in real-time

  We need a full-featured PC.



- Capture AVCHD file (our solution)
  - Copy files in the USB storage of AVCHD cam
  - The capture is done after recording

  We can use any (even virtual) PC with USB2.0.

  We use Linux microserver as auto-recording unit.

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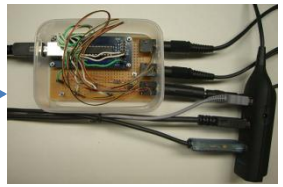
Architecture of our recording system

Auto recording part

AVCHD camcorder



Control circuit

USB2.0 (max 20m)

Auto recording unit

Recording schedule

AVCHD video

AVCHD video (1920x1080)

Schedule management terminal

Video processing server

Videos with virtual camerawork (720x480)

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Topics

- System design
- Automated recording
- Schedule management
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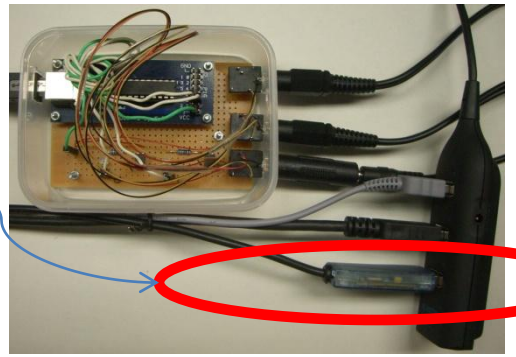
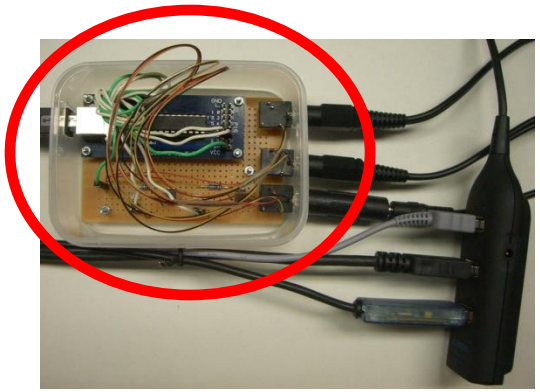
Camcorder control through USB

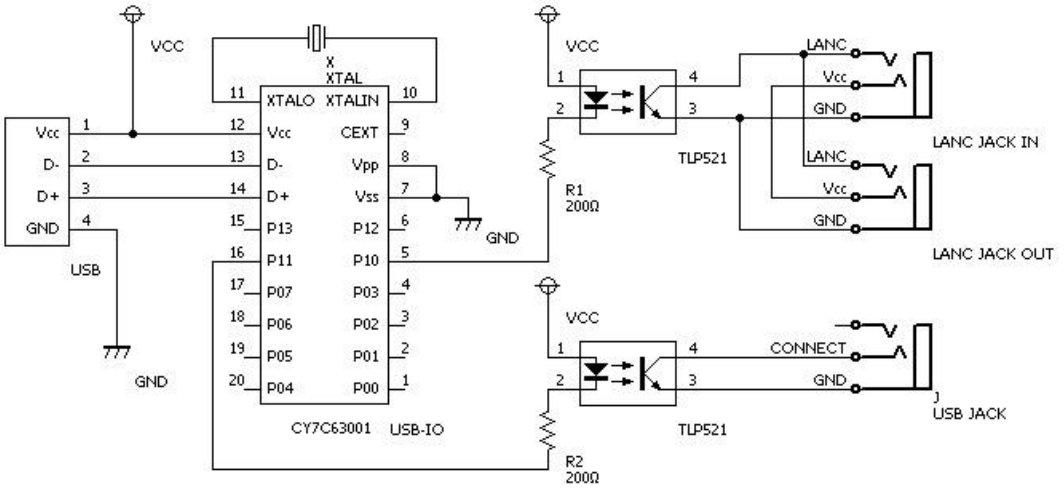
- We use *Sony Control-L Protocol(LANC)*
  - We found “USB to Control-L” adaptor.
    - We can send any Control-L command
    - The adaptor is recognized as HID device.
  - We developed a user-level library on top of *libusb*
- We need a special handling for power-on



Camcorder control by custom control unit

- To power on the camcorder, we need to keep the Control-L signal line at GND level for more than 140ms.
- We developed a relay-circuit with USB-IO
  - The cost is about 20 dollars (2,000 yen).





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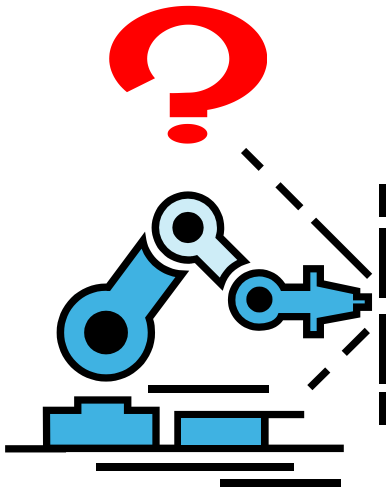
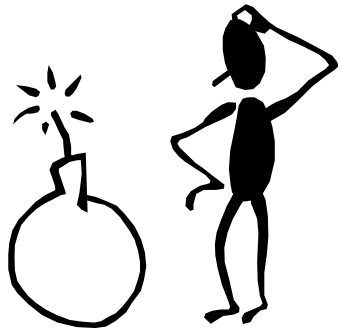
How to automate USB connection

- We need to connect AVCHD camcorder to PC as USB storage before file transfer
- Usually, we need to push connection button by hand.



What is
an economical solution ?



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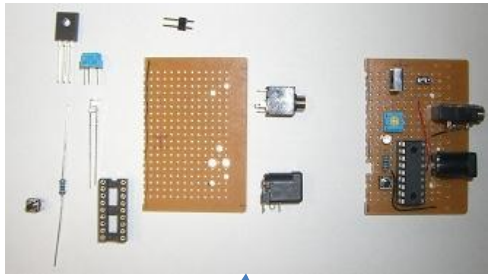
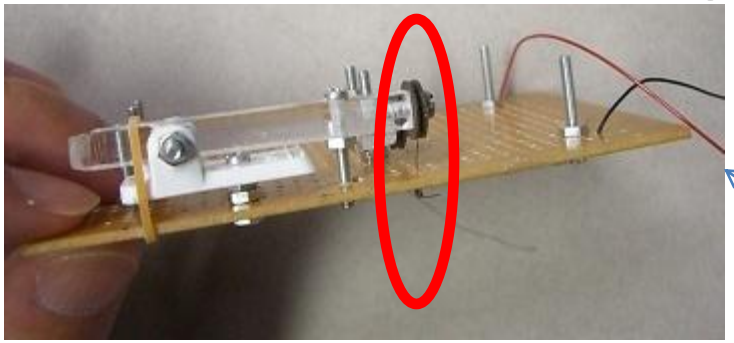
Auto connection by micro actuator

- We need to push the button, but only a little.
  - The stroke to push is 0.2mm.
- We developed a micro actuator
  - *Bio-metal fiber* (artificial muscle)
  - It shrinks in 5% of its length





Total cost is about 15 dollars

  - Power to operate: 5V, 350mA (supplied from USB)

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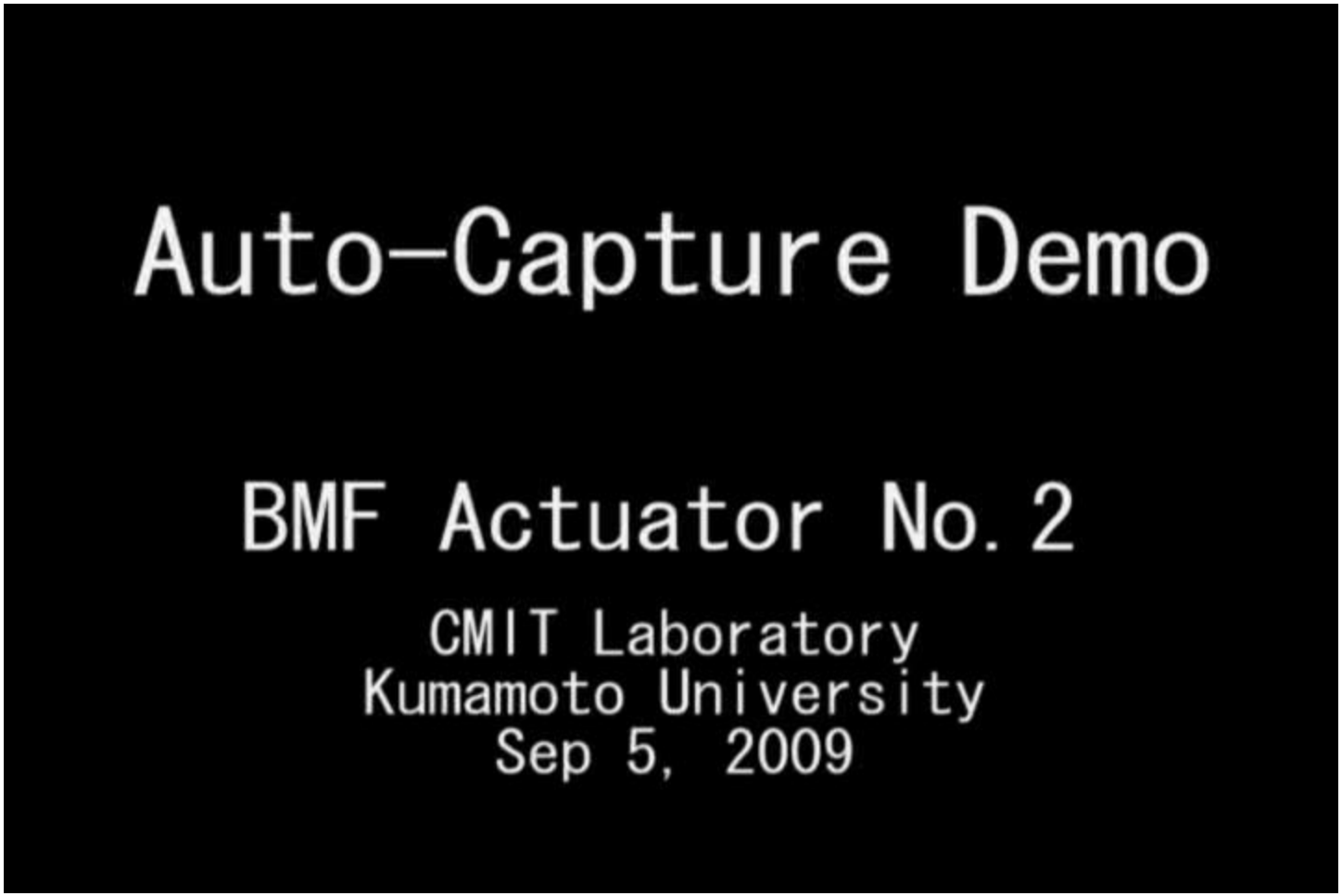
Let’s see how it works



rtsp://atlantis.cc.kumamoto-u.ac.jp/ActuatorDemo.mp4

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Topics

- System design
- Automated recording
- Schedule management
- Video processing
- System deployment

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Management of recording schedule

- Unforseen change is inevitable !
  - Reason: severe weather, wide-spread flu, etc
  - School information system is useless (in our case).
  - The latest recording schedule needs to be updated by teacher or staff.
- We use iCalendar-ready application
  - iCal,Sunbird,

    Google Calendar, etc.
  - Moodle, Sakai,etc.

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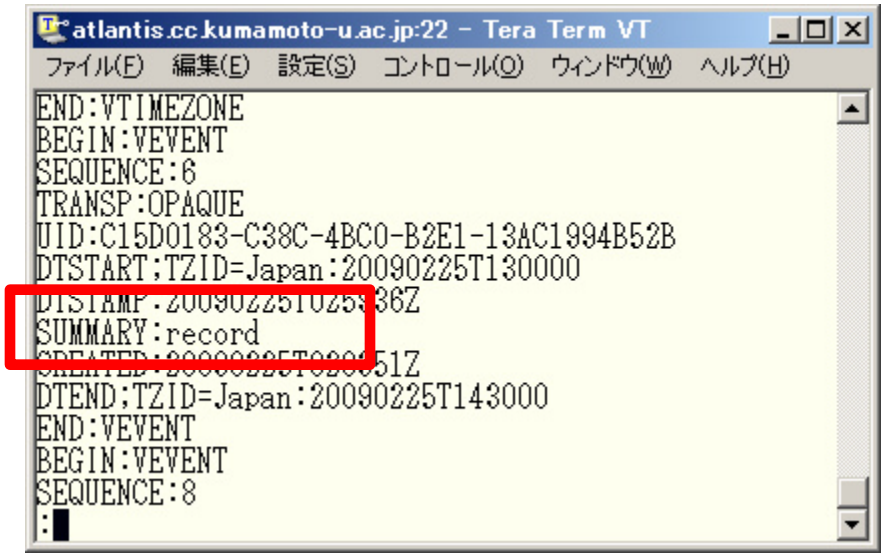
Processing recording schedule

- Convert iCalendar data to crontab



•Schedule server

1. Extract recording of the day
2. Extract SUMMARY field of VEVENT
3. Send commands and times
   to each recording unit.

CMD:powerOn,powerOff,record,capture

•Recording unit

1. Receive commands
2. Convert each command
   to primitive actions
3. Update crontab

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Topics

- System design
- Automated recording
- Schedule management
- Video processing
- System deployment

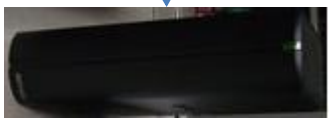
Auto post-processing

- Recording unit
  - When a USB storage is detected, AVCHD files are automatically copied to upload to the video processing server.

    (We can also use the unit for manual capturing)
  - We need to take care of network/server troubles.

AVCHD cam

Recording unit



Temporal spool

Video processing server

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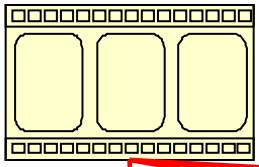
Camerawork generation



1920x1080, 29.97fps

Extract key frames in every 10 frames (i.e. every 1/3 second)

960x540,
256-level gray

Compute differential frames

- Detection of Regions of Interest
  - Split frame into 72x70-pixel blocks
  - Choose the block with the strongest change

We discard student's seats

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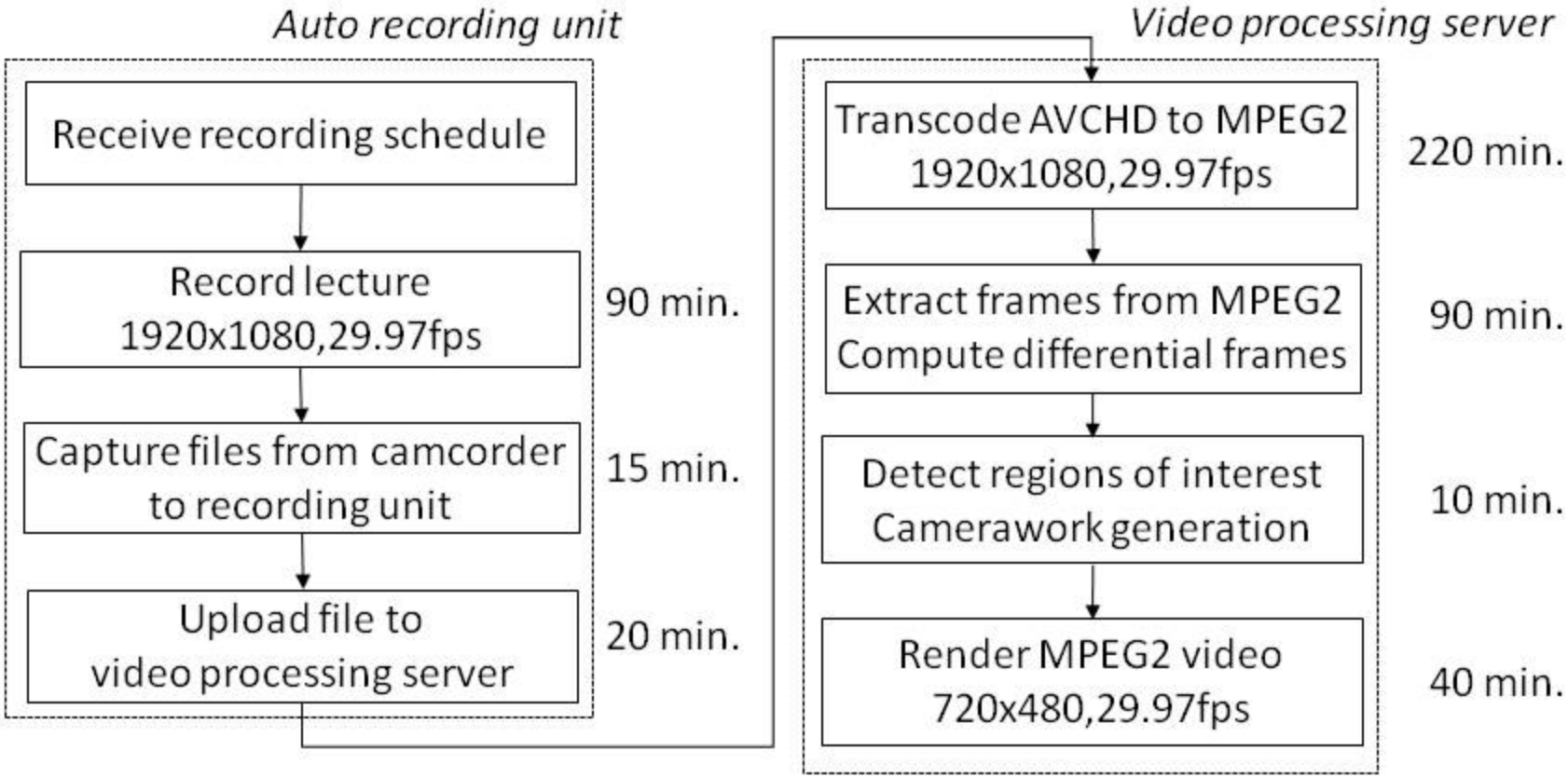
Automated video rendering

- Preprocessing (xport+ffmpeg+Java)
  - Convert AVCHD to MPEG-2
  - Extract JPEG images from MPEG-2
  - Detect regions of interest, compute camerawork
- Video rendering(ffmpeg)
  - Generate video with virtual camerawork
  - We developed an ffmpeg video filter for virtual camerawork effect
- Implemented on Linux and Mac OS X

Workflow

- Under current implementation (Core2 Duo 2GHz), it takes about 6 hours to process 90-minute HDV clip.



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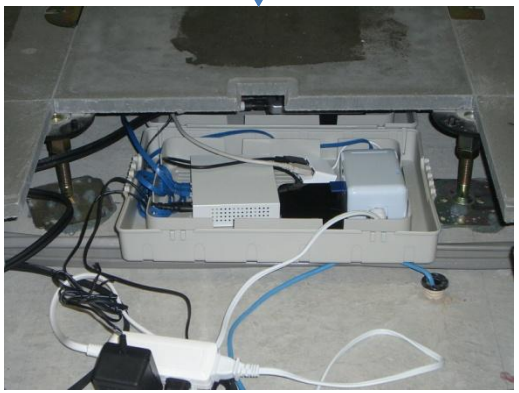
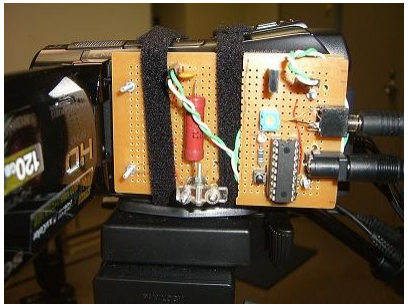
Topics

- System design
- Automated recording
- Schedule management
- Video processing
- System deployment

System Deployment

USB, Audio, AC

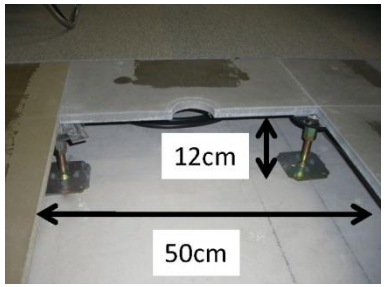




AVCHD Cam
+Micro Actuator

Control Circuit
+Control-L Adaptor
+AC Adaptors

SheevaPlug
+Portable HDD



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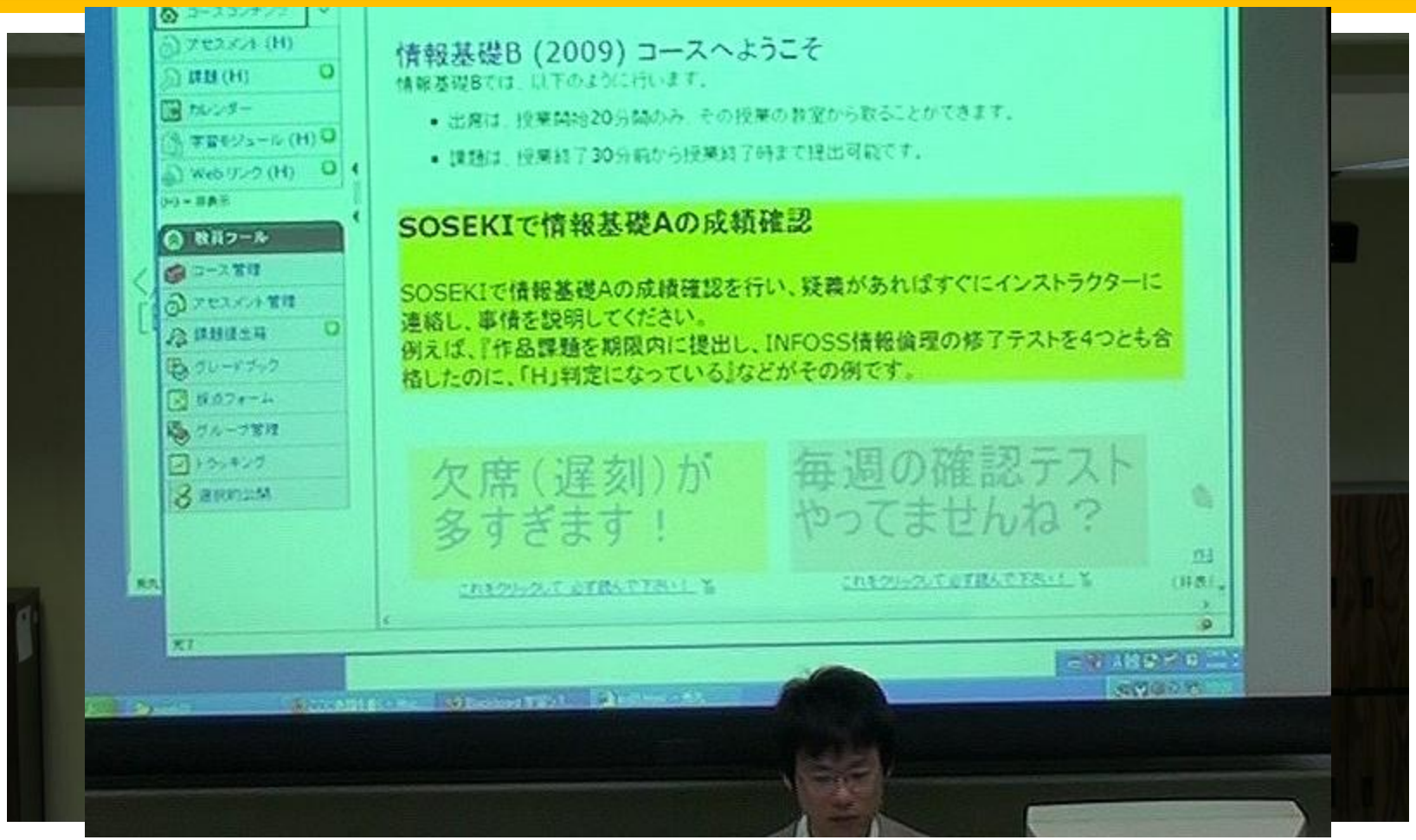
Cameraview



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Cost < $3,000

- Recording unit $1,500
  - HDR-SR12:$1,100
  - SheevaPlug:$100
  - USB HDD:$120
  - Control-L adaptor:$100
  - Control unit:$20
  - Micro actuator:$15

- Video processing server
  - Mac + USB HDD:$800

- Installment work $300
  - Labor cost: $200
  - Shelf, stand, etc:$100

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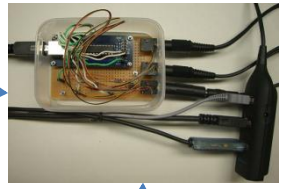
Conclusion

- Automated, cost-effective HD recording
- Low initial cost, easy to deploy
  - $3,000 (1 recording unit + 1 rendering server)

AVCHD video
(1920x1080)



USB2.0
(max 20m)

Schedule
management
terminal

Auto recording unit

Videos with virtual
camerawork
(720x480)

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Future work

- Encode/decode acceleration by hardware
  - Ex. VA API acceleration
- Web UI for camerawork adjustment
- Integration with other systems
  - Moodle, Sakai, Opencast (Matterhorn)
- Web-cam based implementation
  - High-definition Web camera
- Clarify TCO in a long-term deployment

Merits of our auto recording system

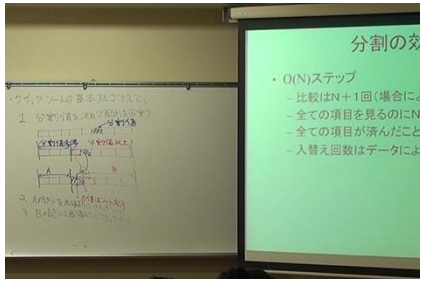
- Open Source solution
  - No license fee, portable
- We can start at a low initial cost
  - Only $3,000 (1 recording unit + 1 rendering server)
- We can also use manual recording
  - Just connect camcorder to recording unit by hand
- We can select implementation of recording unit
  - Desktop PC, laptop PC, netbook, Micro server, Virtual server

Our recording solution

- Recording
  - Use a fixed HDV cam
  - Use 2D barcodes as hints
- Merit
  - No need to manage/train camera operator
  - No need to operate during recording
  - Easy to deploy

1920x1080

- Delivering
  - Use virtual camerawork to convert 1920x1080 video to 720x480 video
- Merit
  - Wide variety of devices are covered (e.g. netbook, iPod,PDA, smart phone)



720x480

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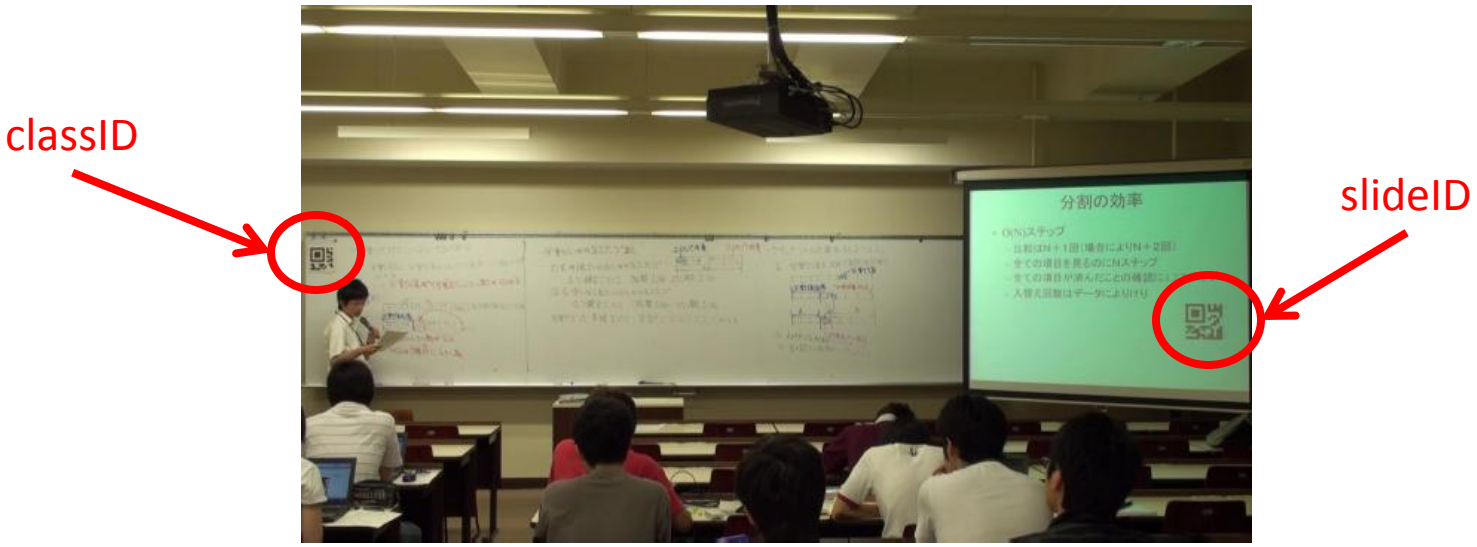
Application of 2d barcodes

- Micro QRcodes（17cmx17cm）are detectable:
  - class ID, slide ID is automatically detected.
  - The location of whiteboard/screen is detectable.



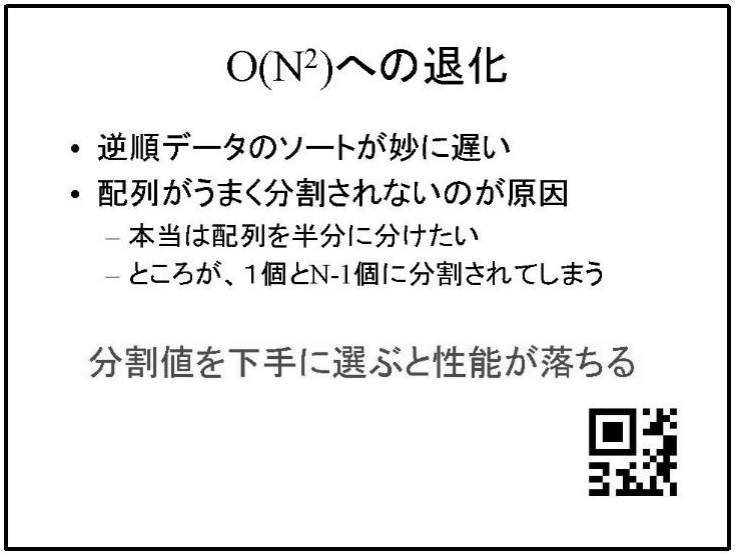
We can automatically determine when which slide is displayed.
We can roughly determine the configuration of the room.

Questions to video staff

- Q1:Are letters on whiteboard/slide readable?
  - Easily readable : 3, readable : 1
- Q2:Is camerawork natural?
  - natural : 2, rather unnatural : 1, unnatural : 1
  - “Sometimes there are unnecessary motions.”
  - “Much better than a poor cameraman.”
- Q3:Is the video useful for reviewing?
  - well useful:4

How to make lecture slides with QRcodes

1. Publish Qrcode images through our course management system
2. Attach the images to slides manually



It takes 5 minutes to attach 20 images to slides by hand.

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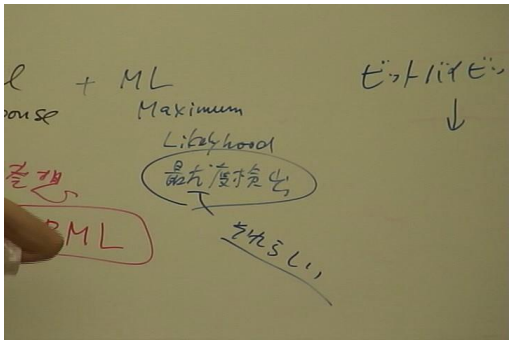
Problems in manned lecture recording

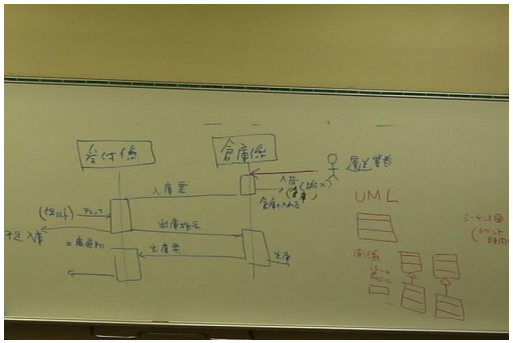
- Shortage of recording staff
  - Constraint by class schedule

    ex. All staff have to attend their classes at a certain day of week
  - Sudden schedule change on the day

    ex. Sickness, job interview
- Differences in skills among recording staff
  - The quality of camerawork, note, etc



Too much zoom



Tilted camera sight

- Graduation of skilled staff