Senbay:
Smartphone-Based Activity Capturing and Sharing Using Sensor-Federated Video

Yuuki NISHIYAMA, Takuro YONEZAWA, Jin NAKAZAWA, Hideyuki TOKUDA
Keio University

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A novel smartphone-based platform for capturing and sharing synchronously-recorded video/sensor data stream using dynamic QR code.
Senbay Camera

Decoded Data Example:

Built-in Sensor (Timestamp, Accelerometer, Gyroscope, Compass, GPS, and more..) + Wireless Sensor (Heartbeat sensor) + Web API (Weather Information)
Background

- **Spread of camera devices**
  - Video Sharing Services/Social Network
    - YouTube
    - Facebook
    - Vimeo
  - YES

- **Progress of sensing technology**
  - Sensor Data Streaming
    - NO
  - Accelerometer, Gyro, GPS
    - Heartbeat, Human Motion, etc.
For sport

For travel and event report

Augmented Analysis & Feedback (Vibration, Visualization, Course Condition)

via social networks and video sharing services

Augmented Reporting

(e.g., location, motion, vital data, and video...etc)

(e.g., location, humidity, temperature, and video ...etc)
Related Work

- Video playback services with sensor data synchronously
  - Kinomap [1], Action Cam Movie Creator (Sony) [2]

- Sensor data embedded technologies for a video file:
  - MPEG7[2], digital watermarking[3], Pixel Translucency Changes[4], etc.
  - SENSEtREAM: Enhancing online live experience with sensor-federated video stream using animated two-dimensional code [5]

Instantly and synchronously integrating those sensor data into videos on smartphones.
Senbay: Smartphone-Based Activity Capturing And Sharing Using Sensor-Federated Video

- [Record]
  Multiple sensor-data stream will be embedded into a video as animated QR code using smartphone (Senbay Camera)

- [Share]
  The “sensor-federated” video (Senbay Video) can be shared easily on the web, through lots of popular video sharing services

- [Analyze]
  Decoding embedded sensor-data in the realtime with Mobile/Desktop Senbay Reader
System Design

Senbay Camera

Social Network/Video Sharing Services

Desktop Senbay Reader

Senbay Extractor

Mobile Senbay Reader

Video Camera on Smartphone

Built-in sensors

Web API

External sensors

Sensor Data (Acceleration, Humidity, Heartbeat, Latitude, longitude, and Speed etc.)

Video Data

TIME:1427521914,127140,LONG:139.495501,LATI:35.306662,ALT:11.2116
37,SPID:5.800000,ACCX: 1.454250.
Why QR code?

- Lots of platforms support QR code.
- High-speed recording is possible.
- Data capacity is enough.

- One QR code can store 4,296 bytes maximally (Case of version 40, level (L))

\[ 4,296 \text{ (bytes)} \times 30 \text{ (fps)} = 128,880 \text{ bytes/sec} \]
**Senbay Camera**

*(Objective-C)*

- Sensor data stream is encoded as animated QR code, and saved it on a video file (**Senbay Video**)
  - Integrating an animated QR code with video in realtime using Open GL ES
- Multiple type of sensor data sources are supported
  - build-in smartphone sensors, additional wireless sensors, Web API
- Sensor data stream is saved as a Key-Value format (compressed it by 121 base-number algorithm)
Demo

Senbay Camera
Mobile/Desktop Senbay Reader (Java & Objective-C)

- Reading a QR code on a **Senbay Video** by a smartphone camera or a virtual desktop camera (such as **CamTwist**)
- Decoding these QR Code in the realtime
- Visualizing decoded sensor data on a window
Demo

Desktop Senbay Reader

Mobile Senbay Reader
**Senbay Extractor**
*(Objective-C)*

- Extracting sensor data from a Senbay Video file
- High-Speed extracting
- Save as a CSV file

The generating process of sensor data file (csv format) from Senbay Video

Demo -Senbay Extractor-
1. **Generating speed of Senbay Video** and energy consumption
   (by using Senbay Camera)

2. **Decoding speed of animated QR code**
   (by using Mobile/Desktop Senbay Reader)

3. **Extracting speed of sensor data from Senbay Video**
   (by using Senbay Extractor)

4. **User studies**
   (by using Senbay Camera & Mobile/Desktop Senbay Reader)
1. Generating Speed of *Senbay Video* and Energy Consumption (by using *Senbay Camera*)

- *Senbay Camera* can generate **over 28FPS video** in the case of iPhone6 (1280x720, 640x480)
  - This FPS is almost the same as the general video (30FPS)

- *Senbay Camera* can be used in general video recording
  - [iPhone 6] .......... around **150 minutes**
  - [iPhone 6 Plus] ... around **200 minutes**

### Table: Relationships of generating speed between devices(chip) and video sizes

<table>
<thead>
<tr>
<th>Device</th>
<th>Chip</th>
<th>Video Size</th>
<th>1920x1080</th>
<th>1280x720</th>
<th>640x480</th>
</tr>
</thead>
<tbody>
<tr>
<td>iPhone 6</td>
<td>A8</td>
<td>14.77</td>
<td>28.03</td>
<td>29.62</td>
<td></td>
</tr>
<tr>
<td>iPhone 5s</td>
<td>A7</td>
<td>14.45</td>
<td>19.81</td>
<td>24.00</td>
<td></td>
</tr>
<tr>
<td>iPhone 5c</td>
<td>A6</td>
<td>8.30</td>
<td>11.54</td>
<td>13.84</td>
<td></td>
</tr>
</tbody>
</table>

### Figure: Energy consumption of iPhone6 and iPhone6 Plus each with video size
2. Decoding Speed of an Animated QR code
(by using Mobile/Desktop Senbay Reader)

• Evaluation procedure
  1) One minute Senbay Video is played back on MacBook Pro 13inch Retina
  2) Senbay Readers decode an animated QR code on the video
  3) We evaluate decoding speed (FPS) by the average of 10 attempts.

• Result
  • Senbay Readers can decode an animated QR code in the almost real time as show in Table

<table>
<thead>
<tr>
<th>Senbay Reader</th>
<th>Frame per Second (Standard Deviation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobile Senbay Reader</td>
<td>26.29 (1.42)</td>
</tr>
<tr>
<td>Desktop Senbay Reader (Objective-C)</td>
<td>24.2 (0.6)</td>
</tr>
<tr>
<td>Desktop Senbay Reader (Java)</td>
<td>55.6 (2.42)</td>
</tr>
</tbody>
</table>
3. Extracting time of sensor data from Senbay Video
(by using Senbay Extractor)

- Evaluation procedure
  - Measuring extracting time of sensor data to CSV File from Senbay Video (1920x1280, 1280x720, 640x480)

- Result
  - Senbay Extractor can export sensor data less than real time
    - 640x480 = [Real Time] x 0.3
    - 1920x1280 & 1280x720 = [Real Time] x 0.6

<table>
<thead>
<tr>
<th>Size of Senbay Video</th>
<th>Export time (sec.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1920x1280</td>
<td>40.377058</td>
</tr>
<tr>
<td>1280x720</td>
<td>42.31606</td>
</tr>
<tr>
<td>640x480</td>
<td>18.836459</td>
</tr>
</tbody>
</table>
4. User-study
(by using Senbay Camera & Mobile/Desktop Senbay Reader)

• Questionnaire for 34 students (19~29 year, 21 male, 13 female) in Keio University

• Evaluation Procedure
  1. Using Senbay Platform
     • Each participants install Senbay Camara and Mobile Senbay Reader
     • They use Senbay Camera and Mobile Senbay Reader
  2. Questionnaire to participant (five scale liker scale)
4. Result of user-study

- From Q1, 70.6% participants said "I want to use Senbay Camera", as positive opinion
- From Q 2 and 3, over 60% participants answers “Decoding QR code is interest and decoding speed is enough.”
- From Q4, 5 and 6, over 70% participants had interested in QR code on Senbay Video and had not feel obstacle
Use-case of Senbay in Sports
-Glider, Ski, Bike, Yacht-
Use-case of Senbay in event report
-Travel, Festival, Disaster, Military Conflict-
Use-case of *Senbay* for Road Condition Analysis

-Travel, Festival, Disaster, Military Conflict-
Discussion and Future Work

• Expansion of data storage
  • Controlling number of QR code and frame rate

• Beauty of Senbay Video
  • using digital watermarking and/or Pixel Translucency Changes

• Drive recorder for Analysis of car accidents
Conclusion

- We proposed **Senbay** that is a novel smartphone-based platform for capturing and sharing **synchronously-recorded video/sensor data stream** using animated QR code
  - Continuously **Senbay** can record video during **200 minutes** and **almost 30 FPS**
  - Based on the above, we discuss possibility of proposed application
Thank you for your kind attention

Senbay Camera and Mobile Senbay Reader are available now

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