
Demo: Support System for Creating Manufacturing Manual using Smartwatches

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Abstract

As digital machine tools like 3D printers have become cheaper and popular, even common people come to involve personal fabrication. There are many web services for sharing instructions; however, people often have difficulty to create such instructions. To solve this problem, we propose a support system to create video instructions for manufacturing using smartwatches. Our system mainly consists of a smartphone application for recording, a Web server for data storage and machine learning platform, and a browser-based application for data presentation and manual tagging. The system can automatically add chapters on video instructions and provide smart fast-forward function.

Author Keywords

Digital machine tools; personal fabrication; smartwatch; motion recognition; manual creation.

ACM Classification Keywords

H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous

Introduction

Recently, web services for sharing instructions of manufacturing processes (e.g., instructables¹ and fable²), have

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¹<http://www.instructables.com/>

²<https://fable.cc/>

become popular. Using such services, even common people can involve manufacturing using digital machine tools such as 3D printers. However, since such instruction manuals mainly consist of pictures and texts, people sometimes have difficulty to understand complicated assembly processes. Moreover, people need much effort to create such manuals. Meanwhile, there are also video instructions of manufacturing, which have advantages to express detailed procedures. However, people need knowledge/skills of video capturing/editing to create comprehensible video manuals. To solve these problems, we propose a support system for creating video manuals using smartwatches. We attach smartwatches on both wrists of a manual creator. The creator records a video of manufacturing processes using a smartphone along with motion data of their hands. Then, the creator (or system) adds “tag” to each action of manufacturing using tagging application. Using such annotations, we possibly develop applications for creating/browsing video manuals: (1) helping a creator to edit video effectively by emphasizing key actions of manufacturing, and (2) supporting a user to search manuals by performing actions. In this paper, we introduce concept, implementation, and application of the system.

Related Work

There are many research projects to support creation of manuals or videos. FabNavi[4] is a support system to record/share assembly processes using a pair of a camera and a projector set above the tabletop. DemoCut[1] is a support system for video editing (e.g., changing play-speed) based on the key frames selected by a creator. QuickCut[3] is a system to summarize videos (e.g., cutting scenes) using voice annotations attached by a creator.

There are many projects that focus on motion recognition techniques using wearable devices. Object Hallmarks[2] utilizes the 9-axis motion sensor of a smartwatch to recognize

held objects and persons. Our system focuses on recognizing actions during manufacturing processes and supporting manual creation using smartwatches and web services.

System Overview

In this section, we describe the configuration of our system (Figure 1). Our system mainly consists of a smartphone application that records manufacturing processes, a web server that stores data and automatically creates tags using machine learning, and a browser-based application for presenting instructions and supporting manual tagging.

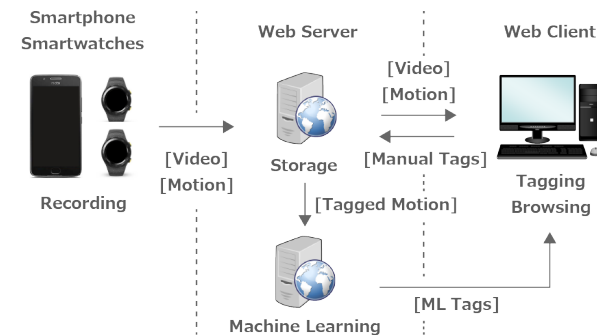


Figure 1: System Configuration

The system mainly focuses on assembly tasks on a workbench using various parts created by digital machine tools like 3D printers and laser cutters. The capture system consists of a smartphone attached over the workbench and smartwatches attached on both hands of a creator (Figure 2). The system records videos of assembly processes using the smartphone and motions of the creator using the smartwatches. Specifically, the smartwatch records movements of both hands during the assembly processes using inertial sensors (3-axis accelerometer and 3-axis gyro sensor). By recording actions in assembly processes as

motion data, the system possibly records “craft techniques” which is difficult to be found just by videos. Next, the creator/collaborator adds “tags” to characteristic actions in the motion data (e.g., using tools or inserting parts) using the tagging application. After a certain amount of tags are stored, the system can automatically add tags to motion data using machine learning. Then, using these tags, the system generates a draft manual including chapters and subtitles. Finally, the creator finishes the manual efficiently based on the draft.

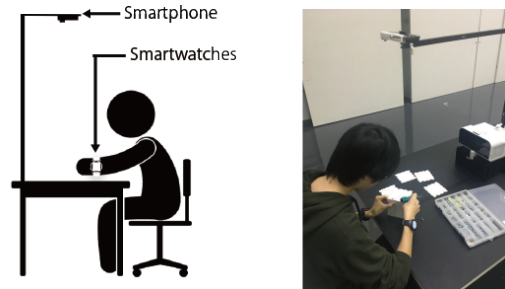


Figure 2: Configuration and appearance of recording system.

Implementation

In this section, we describe the implementation of the system from the aspects of "recording application", "tagging application", "automatic tagging", and "editing application for video manual".

Recording Application

As mentioned in the previous section, recording application consists of a smartphone and smartwatches. We chose an Android phone (MotoG5 Plus) and Android wears (Huawei Watch2) since the Android platform allows to control multiple smartwatches by a smartphone. The smartwatches provide interface for a user to start/stop the recording session. After the recording session is started, the smartwatches

record sensor data (3-axis acceleration / 3-axis angular velocity / heart rate) and transmit these data to the smartphone. The sampling rate was about 50Hz. The smartphone records a video (mp4 format) and uploads it along with the sensor data (CSV format) to the web server.

Tagging Application

After the video and motion data are stored on the web server, a creator may add “tag” to each action in assembly processes using tagging application. The appearance of tagging application is shown in Figure 3. We implemented the application as a web service. The application mainly consists of a video part and a graph part. The graph part visualizes sensor data as line charts and works as video controller and tagging interface. First, when a user clicks on the graph, he/she can change the timeline of the video. The gray vertical line shows the current position. Meanwhile, when the user drags on the graph, he/she can select the range of sensor data (= an action in assembly processes). Next, he/she inputs a tag on the textbox below the graph and clicks the "create" button. Thus, the tag is attached to the action and shown above the graph.



Figure 3: Appearance of web application for tagging.

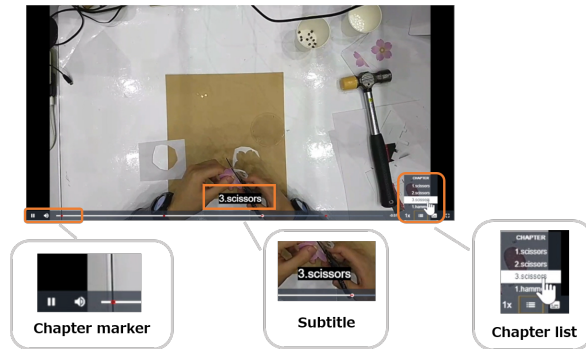


Figure 4: Appearance of web application for creating draft manual.

Automatic Tagging

After a certain amount of tags are stored, the system can automatically add tags to motion data using machine learning. We have developed a prototype method using the sliding window and the DTW (Dynamic Time Warping). The learning data were automatically extracted from the sensor data on the web server using existing tags. The system compare input data (untagged motion data) and learning data using the sliding window. When the DTW distance falls below the threshold, the tag of the learning data is attached to the current range of the input data.

Editing application for video manual

Using the tags attached above, the editing application can generate a draft video manual including chapters and subtitles. Figure 4 shows the appearance of the editing application. Chapters are shown as red markers on the seek bar and also shown in the chapter list. When a user clicks on a chapter in the list, you can change the current position of the video. The editing application also provides editing interface of the chapters and subtitles. Moreover, the system provides summary play function based on subtitles; that

is, the system changes the play speed of the video based on the existence of the subtitles. The play speed becomes slower with the subtitles, while it becomes faster without subtitles.

Conclusion and Future Work

In this paper, we described a support system for creating manufacturing manual using smartwatches. In the future, we will collect large numbers of motion data and try to improve the accuracy and speed of automatic tagging. We also try to develop novel functions for efficient manual creation and browsing.

Acknowledgements

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