AUTOMATIC FIELD WORK TRACING SYSTEM FOR ENHANCED TRACEABILITY

”WORK IDENTIFICATION USING GPS AND SOUND DATA”

Machida Takemi ,Matsumoto Kazunari,Kamiya Takahiro
E-mail:machida@mx.ibaraki.ac.jp
College of Agriculture, Ibaraki University, ami,Inashiki,JAPAN

Abstract

In this study, we examined a system to understand the contents of farm work using both GPS-based positioning data and field voice data while recording them automatically. Precisely understanding location and time from GPS, in addition to going through various processes of partial reasoning, we can reason the contents of farm work using a reference database. It is also possible to get the data from the work track on farm dimensions, operation efficiency, or farm work efficiency. In this system, it is possible to record and analyze data on operation outside the farm field. In order to identify the actual farm work among similarly proposed ones, we developed an algorithm that enables us to make fuzzy reasoning based on GPS information about location, work track, and work speed. The effectiveness of this system has been confirmed. Furthermore, voice and noise data can be useful to analyze and identify work contents as the information on field work is verbally recorded at each site. This operation makes it possible to simplify the record of field work. Therefore, we made research into the voice recording system and the compensation algorithm, together with new audio input methods and speech recognition compensation systems.

Key words: GPS, traceability, speech recognition, cultivation history, Fuzzy reasoning

1. Introduction

We developed the Automatic field work tracing system to enhance the traceability by using GPS and voice hybrid data. The outline of this system is shown in Fig.1.

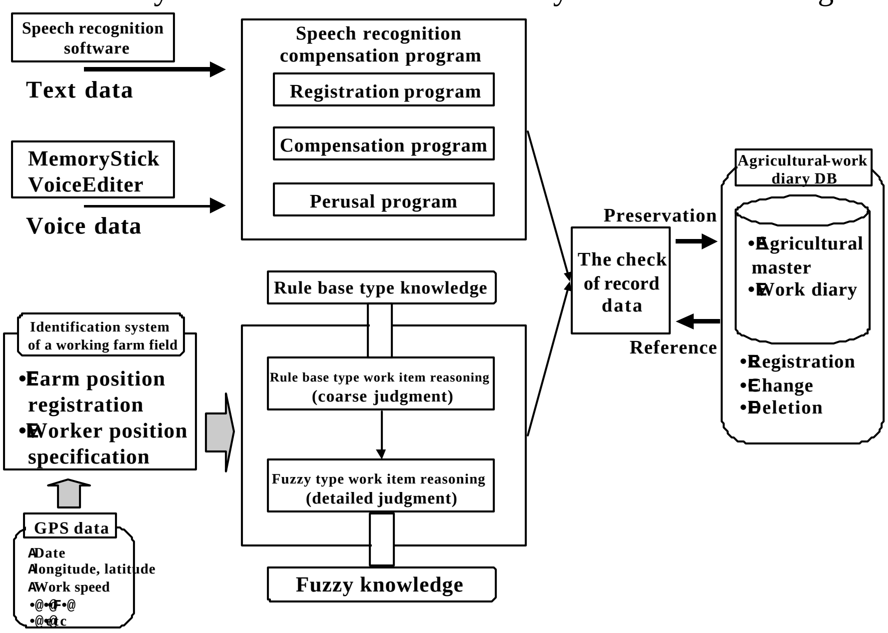


Figure 1. Outline of this system

From the viewpoint of safety and the traceability for agricultural products, information about the production processes of agricultural products is required, and the records of the production site have become much more important. Taking this situation into account in this research, we tackled the task of the automated work recording system at the work site using voice data along with GPS positioning data.

By voice-recording the contents of field work at each site, it is possible to simplify the work, to record field work, and to reduce the workers' burden of keeping a farm journal. And, as it is recorded at each site in real time, more accurate data can be collected in use of GPS positioning data. In addition, the performance of field work can be improved, and the data credibility can be perfectly high enough due to the GPS based operation. It is also possible to use the accumulated accurate data so as to improve the agricultural management and the field work. We made research into the voice and GPS hybrid work recording system and developed the compensation algorithm for voice recognition along with the work identification algorithm by fuzzy theory.

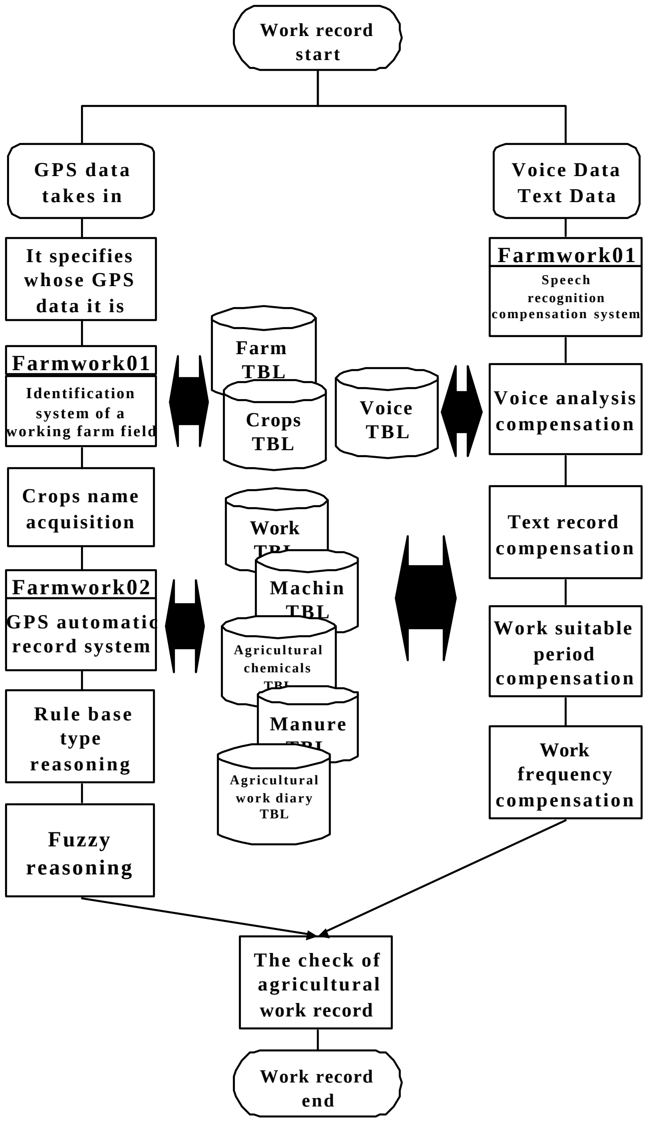


Figure 2. Data flow of this system

The system diagram is shown in Fig.2.

The hybrid system is composed of several main databases:

1) Basic farm database
2) Cultivation database
3) Work diary database
4) Farm machinery database
5) Work item dictionary database

The diagram has two flows in the downward direction: the work identification by using fuzzy theory and the voice data process with several compensation systems. Two divided data flows are combined to analyze the working contents in the final stage.

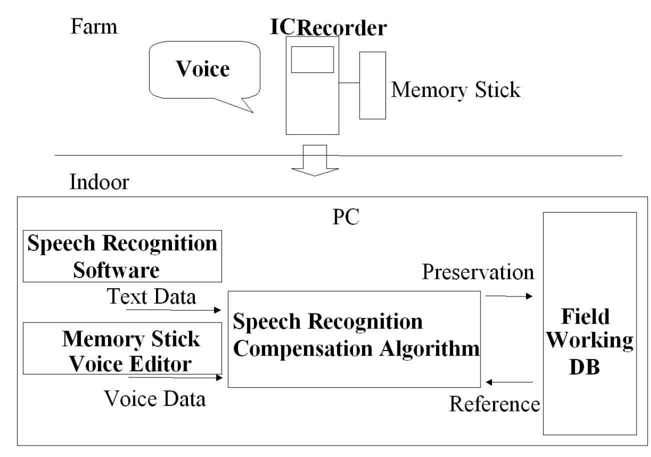


Figure 3. Voice processing flow

2. Speech Recognition

2.1. Structure of the system

An IC recorder provided as a sample was used. It has a function to make folders, each of which is named after the position where the voice is recorded. The recording medium is a memory stick. Dragon Speech Version 5 is used as speech recognition software. Fig. 3 shows the system flow. At first, the worker in the field selects the folder with the name of the position, and then inputs his voice information with the IC recorder. The contents of the information to input are the name of the worker, completion of the work item and memorandums. After the work is completed, the worker acquires the voice file, converts it to text through speech recognition, compensates and preserves it in DB.

2.2. Preparation work and speech recognition

A voice is converted to text by speech recognition software. Before the field work, the worker prepares the folder with the farm name using the folder function of an IC recorder. During the work in the farm, the worker selects the folder with the name of the farm where he works, and then records his name, the work item and completion as one set of information or memorandum that includes e.g., the situations of crops, diseases and pests, used agricultural chemicals, the name of manure. After the field work, the worker acquires the voice file by connecting the memory stick to a personal computer.

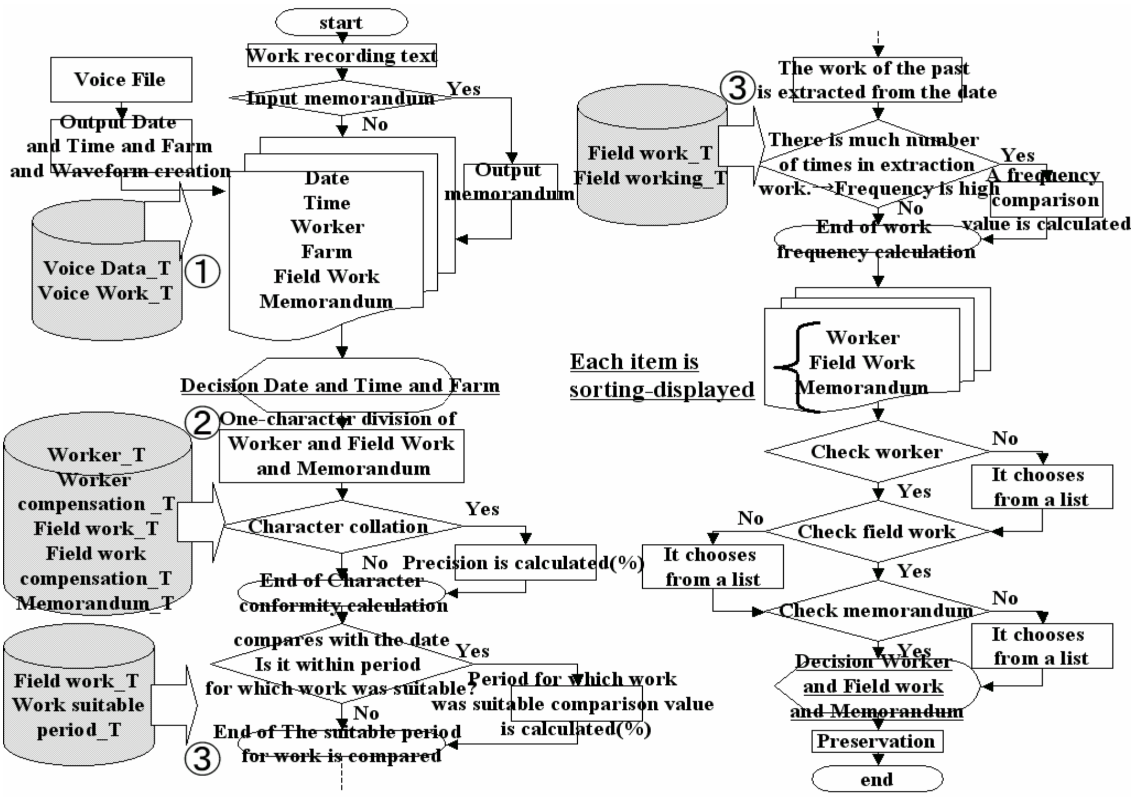


Figure 4 Compensation system flow

Next, the voice file is converted to text by the speech recognition software (sent to the speech recognition compensation program), compensated and preserved in the database.

2.3. Compensation procedure

Fig. 4 shows the flow of the compensation system. Compensation consists of the three items as follows:

a. Compensation of the voice pattern by analyzing the voice file.
b. Compensation of the text record by speech recognition software.
c. Compensation of a work suitable period and work frequency by date.

At first, the system acquires the text from speech recognition software. Then, a) it transforms the voice file to a wave and checks the pattern of the wave. The date, hours and farm name are acquired from the voice file. b) It checks the compatibility at the character level by the text compensation. c) It judges the possible work items and work frequencies, and then sorts them out from the best possible one in descending order.

- Compensation of a voice pattern by analyzing a voice file

Initially, the system extracts the voice data from the voice file, and then it excludes noises and cuts the unnecessary parts. It divides the remaining data into 100, and transforms it to an index of a maximum value of 1. Then, it makes the patterns that show the characteristic of the voice wave per each item.

- Compensation of the text record by speech recognition software

The record converted to the text is compensated by speech recognition software. As there are multiple voice files, in order to sort the data into each item, these files are broken down into individual items, after judged by voice patterns and texts transformed by speech recognition software. The work start time is acquired from the worker's voice file as well as the end time. Each item is compared character by character with the items registered in the database, and the compatibility is calculated. The worker and worker compensation table are paired, therefore, when the compatibility with the items of the worker compensation table is even high or low, the right worker can be chosen, and afterward the compatibility for each item is output. The data of memorandum are also compared with the past data.

- Compensation of a work suitable period and work frequency by date

The work suitable period and work frequency are judged by the date of the voice file. As for a work suitable period, the system selects work items from the work suitable period table 10 days before and after the suitable period. These auxiliary compensated suitable work periods are chosen after the date errors are taken into account. The suitable work period undergoes a change by continued work records. As for work frequency, two processes are made from the work-recording table. The first process is with regard to "the work frequency of past 5 days" during which the number of each work item is divided by the total number of all work items to make a proportion of each item. The second process is with regard to "the work frequency of 5 days before and after the suitable period in the past years concerned ". The calculation is done similarly to that of the first process.

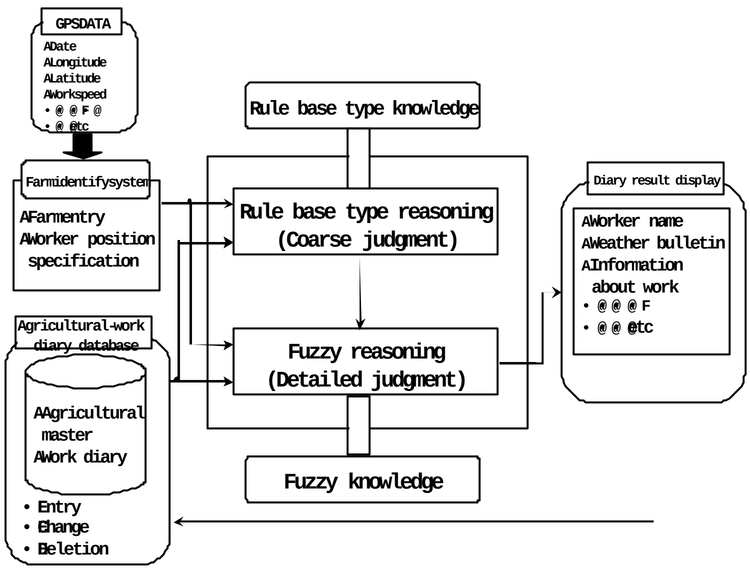


Figure 5. Outline of work identification

3. Field work identification system

Fig. 5 shows the flow of the GPS working identification system. After the work was completed, the data of GPS was input into the computer, which prepared the table that shows the name of the worker, position information, date, hours and moving speed. Following the registered position information, the name of the firm field where the worker was working at the time is returned. Finally, the information such as worker, date, hours, farm field, and work speed is recorded in the database.

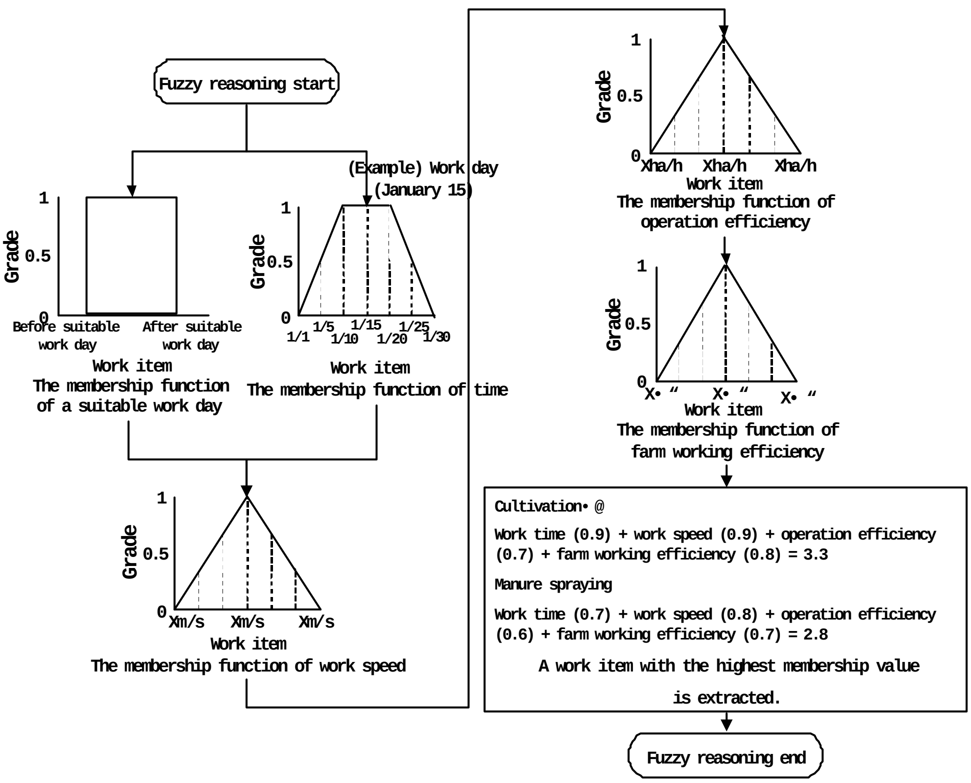
3.1. Division of reasoning work items by Rule base type reasoning

The Rule base type reasoning describes the knowledge in "If-then" form, for example, "If it is A, then it is B". Actually, it carries out the reasoning by determining if "B is determined true if A is true". For the object on which true or false is distinct, the reasoning is carried out based on the clear knowledge. The Rule base type reasoning is aimed at narrowing down the possible work items. This is based on the clear knowledge as follows:

a. Exclude the work completed.
b. Narrow down work items according to the date.
c. Narrow down work items according to weather.
d. Narrow down work items before and after noon
e. Narrow down work items by worker

3.2. Reasoning work items by fussy theory

Fussy reasoning is expressed by Fussy rule and Fussy proposition. Fussy rule is in "If-then" form, and it defines the meanings of each proposition of conditions (If) and conclusions (then) by membership functions. In Fussy reasoning, the general situations such as field tilling and rice-planting are extracted by rule of thumb from, for example, work time: June, work speed: 0.41m/s, operation efficiency: 5.8a/h., farm working efficiency: 65%, and work item. Fig. 6 shows the flow of Fussy reasoning. Firstly, the membership value for the work time is determined. Compared with the work time of last year, membership values are defined such as; membership value of 1 for the period 5 days before and after the day actually worked, membership value 10.5 for the period 10 days before and after the day actually worked, and membership value 1.5.0 for the period 15 days before and after the day actually worked. If the work periods thus generated agree with a suitable work day registered in WorkTBL, the system defines the membership value 1, if not, membership value is 0. Secondly, it defines membership values for work speed, work efficiency and farm working efficiency. Each universal set of 0.X, X-2X of work speed, operation efficiency and farm working efficiency was defined by a Triangle Fuzzy function.



Compared with the work speed, operation efficiency and farm working efficiency of last year, we define the corresponding membership values.

When the work speed, work efficiency and farm work efficiency are closer to their respective set values, the membership values can be proportionally higher. Lastly, we add the membership values of work time, work speed, work efficiency and farm work efficiency so as to extract the work item with the highest membership value.

4. Results

4.1. Voice processing

The recorded screen is shown in Fig.7. Of the three compensation items of the compensation system, several advantages were recognized. First, the compensation item is achieved by voice pattern. This time, as we transformed voices to the waves to compare the characteristics of them, as far as the noises were not big enough to make the characteristics of waves elusive, we could distinguish them. We also recognized some similarities between the voice patterns of different people. Second, the compensation item is determined by text, and for that purpose, a sufficient data is needed. As 3 years of data was available in this experiment, the accuracy of this system improved. Third, the compensation item is determined by the compensation by a suitable work period and work frequency. By investigating the records of actual field work, we noticed that workers tend to do about the same work at about the same period of time. When equivocal elements were found during the compensations of text and voice, a suitable work period and work frequency were used as the factors for judgment. On the other hand, as a suitable work period and work frequency are set in a low priority, supposing that workers do the work items different from a usual manner in prior years, if the possibility by speech recognition compensation and text compensation is high, the possibility by a suitable work period and work frequency becomes low. In this instance, the data is preserved with a flag, which became beneficial in the improvement of work planning, by referring to this flag of data.

Figure 7. Field work recording result screen

4.2. GPS Work Identification

In this system, we researched the possibility of a work identification algorithm using GPS automated work recording and its systemization. By using Rule base type reasoning, we narrowed down the possible work items; by Fussy based reasoning, we finally determined the exact work item, and then we improved the accuracy of the work item identification. We accomplished this because we could acquire remarkable data for the reason that there are different work speeds, operation efficiencies and farm working efficiencies according to the different kind of work items. Although it is possible to narrow down work items by work periods, there are still the cases where the number of work items overlapped. As each machine has its own wo rk speed, the credibility of identifying work items by work speed can be enhanced. When it was impossible to narrow down the number of work items by work speed, we could identify the work items by operation efficiency and farm working efficiency.

5. Conclus ions

Sound and noise data can be useful to analyze and identify work contents, and GPS positioning data can make the field work contents evidently reliable. We can almost completely trace the field work by this system. More in detail, the GPS data can show the detailed positioning in the field, access the relevant DBs when the positioning data are given and identify the field work. On the other hand, voice data can help workers record work contents in detail on the job site. Both the GPS and voice data can be complementary each other, and as a result this research made it possible to enhance the precise traceability.

This system still needs the confirmation by workers before preservation; however, it does decrease the workers' burden of keeping a farm journa l. As the GPS positioning accuracy has improved quite rapidly, the successive accumulation of farm work data, which is based on the work positioning information as basic data, should be of great importance to improve the farm management when linked together with groups of other data.

REFERENCES

Seiji Yasunobu(1991)Fuzzy Engineering,Syoukoudou,134-138p
Machida Takemi(1996)Automatic field recording system by using GPS, JSAI Vol 4 No.2
Teruaki Furui(1998)Sound information processing,Morikita,173pp
Ishi Naoki(2002)Sound processing by use “ONSEIKOBOU”,Colona,156pp