Fuzzy Reasoning for Optimization of Washing Processes

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***Abstract*— The wardrobe of a household contains a mass of clothes produced from different textile. Each producer describes the optimal washing and handling parameters for own product. But the laundry basket contains different clothe pieces. The purpose of a housewife is the choosing of optimal washing and handling parameters to save the quality of clothes and to spare water, detergent, and energy. This paper focuses on an intelligent washing machine controlled by fuzzy logic to optimize the washing processes.**

I. INTRODUCTION

The Intelligent Home project in Alba Regia University Center of Óbuda University was started five years ago, in 2006. The aim of this project was the research of ambient systems for the optimization of family household processes. In the focus was the integration of them into the processes of information society to satisfy the people's all day's needs. [1]

The Intelligent Home project consists of four activities and covers the main processes of a household

- Intelligent Fridge (started 2006)
- Intelligent Washing Machine (started 2007)
- Intelligent Lighting System (started 2006)
- Intelligent Security System (started 2007)

This paper will present the last phase of Intelligent Washing Machine project. [2]

II. RFID IDENTIFICATION

The technology of RFID (Radio Frequency Identification) opened a new horizon for automatic identification articles in retail [3]. The RFID technology supports the recognition of each piece of object by radio waves therefore can be widely used for identification of persons, or several types of products.

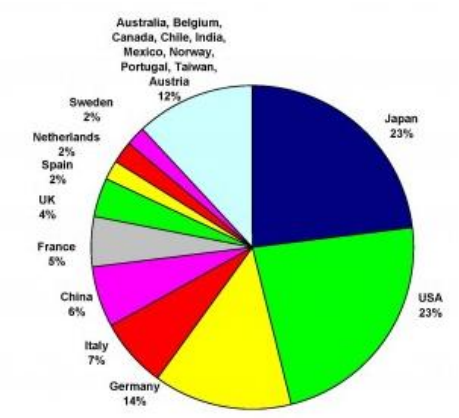

Figure 1. The distribution of RFID users in apparel by country

Figure 2. RFID passive tags

The main advantage of RFID technology is that this technology doesn't require direct or optical contact with the objects. RFID data can be read through cover, wrapper, cloths, animals' or human body, too. Any restrictions of RFID use can cause the liquid and metallic substances. The data capacity of RFID tags mounts in depends of type from couple of bytes up to more Kbytes.

A. RFID in Apparel

In retail is very relevant the supplementary costs, for example, the cost of etiquettes in compare to the article's price. The identification system must be simple and safety, as well. The apparel is an appropriate field of application for RFID in this sense.

Fig. 1 shows the distribution of RFID users in apparel branch by country.

"The RFID tagging of apparel is now the largest and fastest growing application of RFID in retailing, the retail supply chain and associated industries. About 100 organizations are tagging apparel in trials and rollouts. Just two – taken together – will buy 500 million tags yearly soon. According to new IDTechEx analysis, the systems and tag business concerned with apparel RFID will grow at double the rate of the overall RFID market through the next ten years." [4]

B. RFID Tags

RFID tags are either active or passive. The active tags are robust and expensive. They use internal battery and the stored data can be modified or rewritten. The read range is quite large.

Fig. 2 presents passive RFID tags which work without internal battery, the power supply will generated by

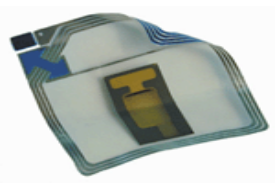

Figure 3. Conventional etiquette

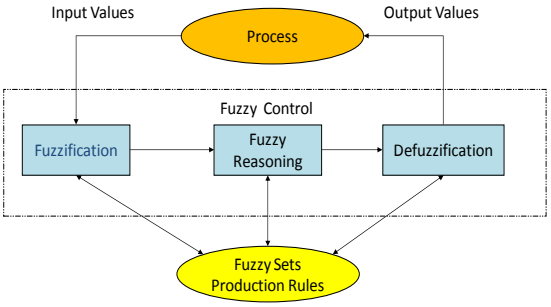

Figure 4. Model of fuzzy control system

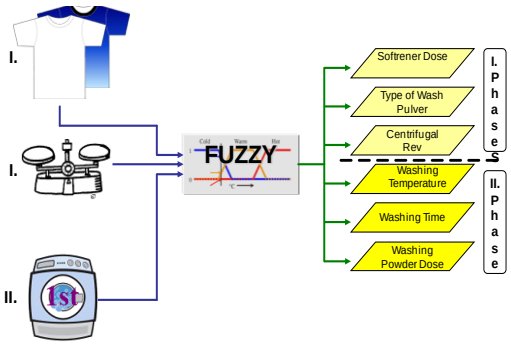

Figure 6. Input and output parameters

reader. The passive tags guarantee less read distance, have less memory, theoretical unlimited lifetime, they are smaller and cheaper as the active tags. In the systems using passive tags, they are used only for object's identification, the related data will be stored not in the tag's memory but in the database of the system.

Fig. 3 presents a type of conventional etiquette. They can be based either on bar code or RFID technology but normally will removed by the user immediate after purchase. In view of the further identification of clothes tags must be hidden in the buttons, buckles, or other accessory in the future.

III. Fuzzy Reasoning

The fuzzy logic conceived by Latfi Zadeh, and the on it based fuzzy systems are a quite new, and perspective field of artificial intelligence. [5, 6] This approach to special set theory was widely applied in the knowledge based and expert systems, decision support systems, database systems, control systems, etc. where probability, linguistic variables, and also human art problem solving are accented. Fuzzy systems not required a precise, numerical information input, and they are able for adaptive control.

A. The Fuzzy Control System

Fig. 4 presents a typical model of a fuzzy control system. Fuzzy logic operates with linguistic variables represented in form of 'IF X AND Y THEN Z' type production rules that define the desired system output response for given system input conditions. The advantage of this approach is that the rule set can be easily modified by the end user of the system. [7, 8, 9]

The parameters measured on the real process, or acceded from a data base have to convert to a weighted linguistic variable. This weight expresses the membership of this variable to the related set and has a value between 0 and 1. The process of transformation holds the name of fuzzification. The membership function is a graphical representation of the magnitude of participation for each input value.

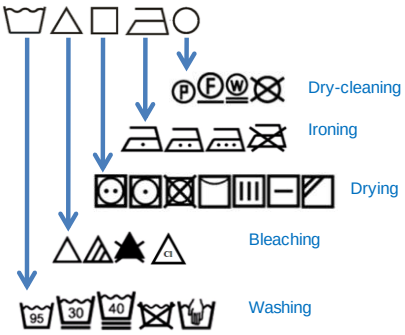

Figure 5. Handling parameters of textiles

By the fuzzy reasoning the rules are used to determine the final output conclusions in depend on the input membership values as weighting factors and their influence on the fuzzy output sets.

After the fuzzy reasoning the concluded linguistic output variables have to be translated into a crisp value. This process is named as defuzzification. A simple and widely used defuzzification technique is the method of gravity's center. The output values affect as a feedback on the controlled process.

Fuzzy control systems can be implemented in hardware, software, or as a combination of both.

B. Input and Output Parameters

Fig. 5 shows the typical handling parameters of textiles.

Fig. 6 presents the input and the output values of intelligent washing system. For incoming values were chosen

- common handling parameters of clothes given by manufacturer, or modified by user in the database
- summarized weight of clothes
- measured dirty of clothes

The outgoing washing parameters are

- the softener dose
- type of detergent
- centrifugal speed
- washing temperature
- washing time
- detergent's dose

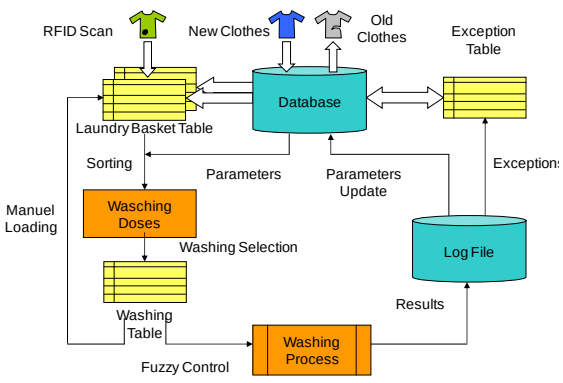

Figure 7. Data flow of intelligent washing system

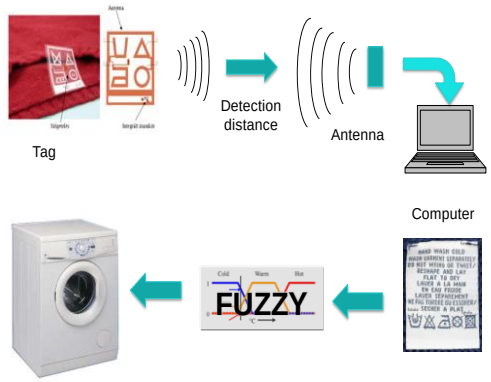

Figure 8. RFID identification

IV. System Implementation

The hardware model of intelligent washing system consists on a pocket personal computer with touch screen, RFID reader with experimental tags, and a weighing machine. [1]

A. The Intelligent Washing System

Fig. 7 presents the data flow of intelligent washing system. The basic dates of clothes are stored in the database. The pieces of clothes throwing into one of the laundry baskets will recorded in the laundry basket table.

The sorting program regularly checks this table and respecting the washing parameters of each piece try to complete and optimize the washing doses. The selected dose will moved to the washing table which content can be manual revised.

Fig. 8 shows the recognition and identification process of clothe pieces. On the base on all of given parameters the program using fuzzy logic calculates the optimal washing program, the softener dose, type and dose of detergent, centrifugal speed, and washing temperature. The reader in the washing machine checks the real material process and compare it with the actual content of the washing table.

The results of washing process will be recorded into the Log file. Based on Log file the program can handle any exceptions, and parameter's update in the database. The junked pieces of clothes will be removed from database.

B. The Realization of Fuzzy Reasoning in FLUtE

The fuzzy reasoning system of intelligent washing machine was implemented in FLUtE (Fuzzy Logic Ultimate Engine) environment which initially was developed by Department of Electronics and Information in Milano Polytechnics.

FLUtE is a fuzzy logic engine based on Microsoft .NET framework technology and written in programming language C#. This an open-ended engine allowing users to implement both a standard implementation of commonly used fuzzy logic techniques and user defined algorithms.

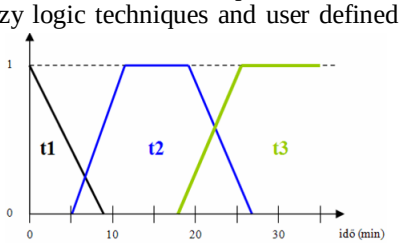

Figure 9. Membership function used for washing time

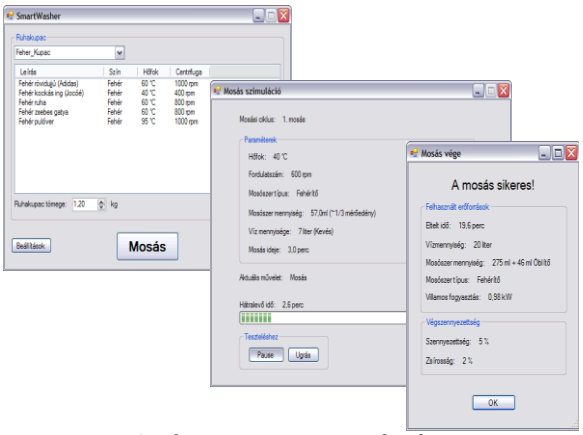

Figure 10. The reasoning process realized in FLUtE

The engine is delivered as a DLL (Dynamic Linked Library) that can be used inside of any Microsoft® .NET project.

C. The Membership Functions

The linear characteristics are the simplest method for membership function. The determination of membership functions in FLUtE environment is not complicated.

Fig. 9 presents the membership function of washing time. Three categories are created 'Very short', 'Short', and 'Medium'.

Determination of membership function t1 'Very short':

```
<POINT X-Value="0" Y-Value="1"/>
<POINT X-Value="9" Y-Value="0"/>
```

Determination of membership function t2 'Short':

```
<POINT X-Value="5" Y-Value="0"/>
<POINT X-Value="12" Y-Value="1"/>
<POINT X-Value="19" Y-Value="1"/>
<POINT X-Value="27" Y-Value="0"/>
```

Determination of membership function t3 'Medium':

```
<POINT X-Value="18" Y-Value="0"/>
<POINT X-Value="25" Y-Value="1"/>
<POINT X-Value="35" Y-Value="1"/>
```

The next step was the assignment of fuzzy sets to the output variables. For example, the measured dirty of clothes as input variables:

```
<FuzzySet Name="Kissé koszos"
    MembershipFunction="Low"/>
<FuzzySet Name="Közepesen koszos"
    MembershipFunction="Medium"/>
<FuzzySet Name="Nagyon koszos"
    MembershipFunction="High"/>
```

The washing time as output variables.

```
<FuzzySet Name="Nagyon rövid" MembershipFunction="t1"/>
<FuzzySet Name="Rövid" MembershipFunction="t2"/>
<FuzzySet Name="Közepes" MembershipFunction="t3"/>
```

Production rules describing the relation between measured dirty of clothes and washing time:

```
<IF>
<RuleCriteria VariableName="Szenny" SetName="Nagyon
    koszos"/>
<RuleCriteria VariableName="Zsir" SetName="Nem zsíros"/>
</IF>
<THEN>
<RuleCriteria VariableName="Ido" SetName="Közepes"/>
</THEN>
```

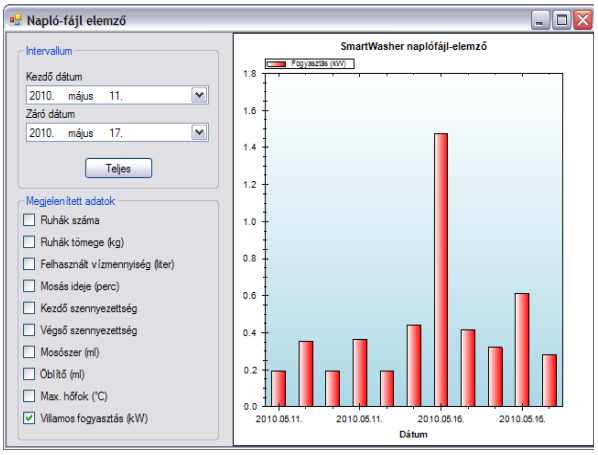

Figure 11. The user interface of Log file analyzer

Fig. 10 presents the user interface of fuzzy reasoning program and Fig. 11 shows the Log file analyzer. The Log file analyzer was implemented in free DLL environment ZedGraph which can simple interact with the Microsoft® .NET applications.

V. Conclusions

In this paper presented intelligent washing machine system is a model based on fuzzy reasoning for optimizing of washing processes and carefully handling clothes to save the quality of them and to spare time, water, detergents, softener, and energy, as well.

Acknowledgment

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