# A Fuzzy Expert System for Designing Customized Workout Programs

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***Abstract*—Due to the change in life style and diet, modern people suffer from obesity, diabetes, and other types of diseases. Regular practice of exercise can alleviate the negative effects from the diseases and even cure the diseases in certain cases. In addition, regular practice of exercise improves the quality of life. These facts have drawn much attention and people nowadays recognize the importance of exercise. As a result, more and more people hope to start exercising but they lack the knowledge of how and what to exercise. Professional counseling costs relatively expensive and thus it is difficult for ordinary people to access a counselor. To tackle these issues we propose a fuzzy expert system that designs a workout program. The system receives user's body information, preference on exercise style, and available time. Then, the system generates a customized workout program based on fuzzy reasoning. We conduct experiments to verify the performance of the proposed system. The participants enter their body condition, preference and available time and receive customized workout programs from the system. The experiments verifies the applicability of the system. The future research includes the extension of the system to meet various user demands and to reflect a number of expert knowledge sources.**

## I. Introduction

The modern life style of human has changed dramatically from that of the past due to industrialization and civilization. People spend more time sitting on a chair rather than moving around and consume more processed foods rather than natural organics. The significantly reduced amount of body movement during a day and the change of diet cause serious problems to modern people [1]. For example, more than 35% of U.S. adults are obese [2] and they suffer from type 2 diabetes mellitus, gallbladder disease, coronary heart disease, high blood cholesterol level, high blood pressure, or osteoarthritis [3]. Recent studies have shown that people can handle these problems by exercising in a regular manner [4, 5]. Exercise-induced weight loss reduces obesity and related comorbid conditions in both men and women. Moreover, even some chronic diseases common in modern men can be cured by an exercise therapy [6, 7]. Doctors could prescribe exercise therapy specifying the type and amount of exercise according to the type of disease. It has been shown that the physical activity significantly improves patients' health.

Other than the purpose of disease therapy or prevention, health management through a regular exercise program improves the quality of life as well [8-11]. Studies have proved that patients, children and old adults experienced improvement of life quality with exercise. As this is the case, more and more people start to realize that exercise is an effective way of keeping both mental and physical health. However, people do not know where to start when they actually try to put exercises into their lives. Some stop by personal training (PT) centers only to find that cost of PT is expensive. Although a few of them begin to exercise with a professional personal trainer, each personal trainer has a different approach and they fail to provide a customized and consistent workout program for each user. People wish to receive a fully customized and structured service.

In this paper, we propose a fuzzy expert system that designs a workout program to tackle the above-mentioned problems. To the best of our knowledge, this is the first attempt to design a fuzzy expert system for workout programs. The system collects three types of user inputs: body information, preference on exercise style, and available time. Then, the system produces a customized workout program reflecting the information the user provides. The expert system designs workout programs based on fuzzy reasoning. Since each user expresses his/her opinion in a natural language, their requests are vague unavoidably. Furthermore, user's physical state varies in a wide range, so their physical states also contain vagueness. Therefore, the fuzzy expert system is developed to deal with the vagueness embedded in the user information. Our key contributions are as follows: i) we present an approach for constructing a fuzzy expert system that designs workout programs reflecting user demands, ii) we design an architecture consisting of the user data preprocessing unit and the workout program design unit, iii) we consider user's current body state, user's preference on exercise style and available time for exercises in designing a workout program, iv) we implement our system as a computer program and use it for a user study, and v) we verify our design by conducting experiments and analyzing the products from the system.

The rest of this paper is organized as follows. Sections II and III describe the proposed fuzzy expert system. Section IV shows the experiment setup and the results. Section V discusses further works. Finally, concluding remarks follow

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in Section VI.

## II. System Overview

The overall system architecture is illustrated in Fig. 1. Two main units comprise the system: the user data preprocessing unit and the workout program design unit. The user data preprocessing unit receives the information needed for designing a customized workout program from the top layer which represents the user inputs. A user needs to enter his/her bioelectrical impedance analysis (BIA) result which contains the user's physical body information such as weight, muscle mass, fat mass, and total body water [12, 13]. The user also specifies what type of workout program he/she prefers. The user can choose among three options: power lifting, core workouts, and overall fitness. The last information the user conveys is the available time for exercise. These user inputs are crucial for the system to customize the workout program for the user.

The workout program design unit is composed of the workout extraction layer and the scheduling layer. The values to the input variables of the workout extraction layer are assigned by the user data preprocessing unit after processing the information presented by the user. For this, the unit makes the raw data go through the fuzzification process. The fuzzification process generates fuzzy variables. Detailed explanation on the fuzzification process appears in the following sections. The workout extraction layer receives values for the fuzzy variables. Then the layer extracts proper exercises for the user using fuzzy inference. This layer contains the rule base which sets the criteria for choosing the proper types of exercises. The rule base is formed based on expert knowledge. Part of Schwarzenegger's work [14] is used for the generation of the rule base. The workout extraction layer delivers a list of exercises to the scheduling layer. The scheduling layer arranges the selected exercises into the time table. For the arrangement, the characteristics of each exercise are considered. As a consequence, different parts of the body will be evenly worked out in a day. The factors that determine the exercise characteristics are listed in the following section.

## III. The system design

### A. Preprocessing of User Data

In our system, users specify their body condition, preference, and available time. However, user inputs vary in a broad range, thus the data contain vagueness. A fuzzy expert system can deal with such uncertainty in a delicate way. For the system to operate with the information users provide, the data need to be fuzzified. The preprocessing unit fuzzifies the input data and delivers them to the next unit. Table 1 clarifies the process of fuzzification. The first column of the fuzzy variable table shows the fuzzified variables. These variables become the input variables for the workout program design unit. The second column of the same table specifies the fuzzy numbers for each variable. The abbreviations are as follows: 's' for 'standard', 'as' for 'above standard', 'has' for 'highly above standard', 'bs' for 'below standard', 'hbs' for 'highly below standard', 'b' for 'balanced', 'ub' for 'unbalanced', and 'hub' for 'highly unbalanced', respectively. The third column of the table exhibits the specification of membership functions. A triangular membership function is used for the fuzzification process. Each number in the bracket stands for a branch point of the membership function. Parts of the input data are delivered without being processed. Such data are sex, weight, height, and preference. Table 2 displays these variables.

### B. Workout Extraction Algorithm

The overall procedure of the workout extraction algorithm is depicted in Fig. 2. The algorithm determines the intensity of the workout program and the types of the exercises using the fuzzy and crisp variables coming from the previous unit. The first stage computes the intensity based on the user's body condition. The result is expressed in two variables: $Num\_Set$ and $Num\_Rep$. $Num\_Set$ and $Num\_Rep$ represent the number of sets and the number of repetitions in a set, respectively. If the user is strong enough, then the user can go through a hard training. In the hard training, lower numbers of sets and repetitions are used [14]. On the other hand, higher numbers are used for novices. Another function of the 'How to' stage is the determination of running time and speed. Running is one of the aerobic exercises that are recommended for people with high BMI or unbalanced muscle distribution. The 'How to' stage calculates the degrees of BMI and muscle distribution and chooses the time and speed based on the degrees.

In the following phase, exercises are chosen based on the user preference. According to the preferences, different types of exercises are preferred in general. However, it does not mean that exercises are classified according to the preferences, but preferences assign priorities on the exercises. If the body condition of the user is not apt for certain types of exercises, then the system would recommend other types of exercises against the user's preference. Table 3 presents the list of exercises provided by the system. Twenty types of exercises are classified in four ways: whole or upper or lower body, aerobic or anaerobic, compound joint or isolated movement, and weighted or body-weighted. Isolated movement exercises are not included in this database. The reason is that the current system does not accept the bodybuilding preference. The classification is important in choosing the best exercises for the user in that the categories best match the need of the user. The rule base makes multiple decisions based on this information and chooses the proper types of exercises. Finally, the workout extraction layer delivers the list of exercises and the intensity to the scheduling layer.

### C. Scheduling Algorithm

The scheduling layer arranges the exercises the workout extraction layer has selected. In the arrangement process, user preference, types of exercises, and time constraint are considered. User preference sets priorities among the exercises. 'Power lifting' programs generally include compound joint and weighted exercises. 'Core workout' programs select the core exercises first and the body-weighted second. 'Overall

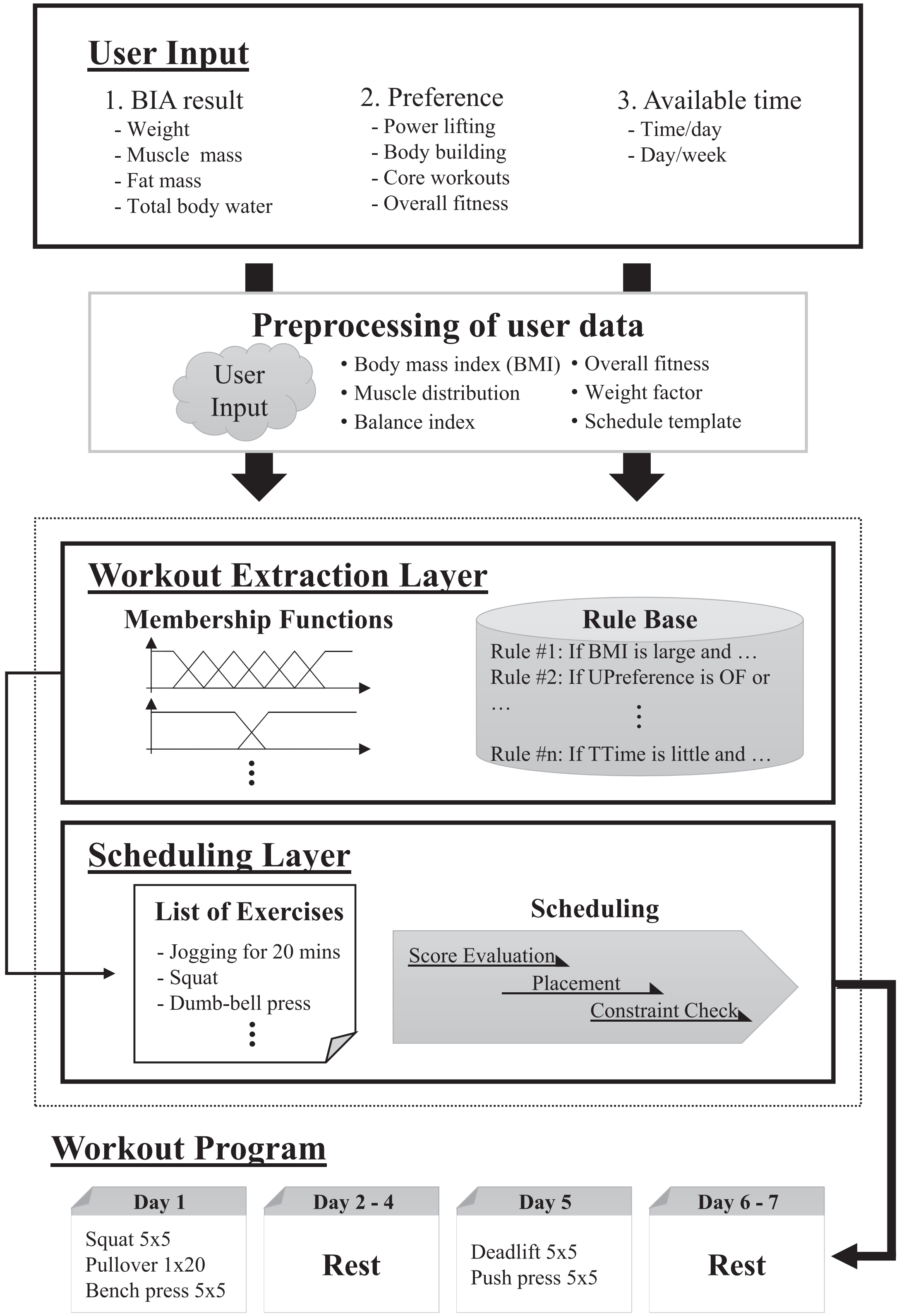


Fig. 1. The architecture of the proposed fuzzy expert system. The system consists of two major parts: user data preproceessing unit and the workout program design unit. The preprocessing unit extracts values for the input variables of the workout program design unit. The design unit has two-layered structure. The first layer chooses the best exercises for the user and the second layer schedules the workout program accordingly.

TABLE I
FUZZY INPUT VARIABLES FOR THE WORKOUT PROGRAM DESIGN UNIT

| Fuzzy Variable | Fuzzy Number | [a, b, c] |
|---|---|---|
| Overall_Fat (OF) | OF_hbs | [Mean_OF-2.25SD_OF, Mean_OF-1.5SD_OF, Mean_OF-0.75SD_OF] |
| | OF_bs | [Mean_OF-1.5SD_OF, Mean_OF-0.75SD_OF, Mean_OF] |
| | OF_s | [Mean_OF-0.75SD_OF, Mean_OF, Mean_OF+0.75SD_OF] |
| | OF_as | [Mean_OF, Mean_OF+0.75SD_OF, Mean_OF+1.5SD_OF] |
| | OF_has | [Mean_OF+0.75SD_OF, Mean_OF+1.5SD_OF, Mean_OF+2.25SD_OF] |
| Overall_Muscle (OM) | OM_hbs | [Mean_OM-2.25SD_OM, Mean_OM-1.5SD_OM, Mean_OM-0.75SD_OM] |
| | OM_bs | [Mean_OM-1.5SD_OM, Mean_OM-0.75SD_OM, Mean_OM] |
| | OM_s | [Mean_OM-0.75SD_OM, Mean_OM, Mean_OM+0.75SD_OM] |
| | OM_as | [Mean_OM, Mean_OM+0.75SD_OM, Mean_OM+1.5SD_OM] |
| | OM_has | [Mean_OM+0.75SD_OM, Mean_OM+1.5SD_OM, Mean_OM+2.25SD_OM] |
| BMI | BMI_hbs | [Mean_BMI-2.25SD_BMI, Mean_BMI-1.5SD_BMI, Mean_BMI-0.75SD_BMI] |
| | BMI_bs | [Mean_BMI-1.5SD_BMI, Mean_BMI-0.75SD_BMI, Mean_BMI] |
| | BMI_s | [Mean_BMI-0.75SD_BMI, Mean_BMI, Mean_BMI+0.75SD_BMI] |
| | BMI_as | [Mean_BMI, Mean_BMI+0.75SD_BMI, Mean_BMI+1.5SD_BMI] |
| | BMI_has | [Mean_BMI+0.75SD_BMI, Mean_BMI+1.5SD_BMI, Mean_BMI+2.25SD_BMI] |
| Balance_top_lr (BTLR) | BTLR_hub | [5%, 10%, 10%] |
| | BTLR_ub | [0%, 5%, 10%] |
| | BTLR_b | [0%, 0%, 5%] |
| Balance_bottom_lr (BBLR) | BBLR_hub | [5%, 10%, 10%] |
| | BBLR_ub | [0%, 5%, 10%] |
| | BBLR_b | [0%, 0%, 5%] |
| Balance_top_bottom (BTB) | BTB_hub | [5%, 10%, 10%] |
| | BTB_ub | [0%, 5%, 10%] |
| | BTB_b | [0%, 0%, 5%] |
| Arm | Arm_hbs | [Mean_Arm-2.25SD_Arm, Mean_Arm-1.5SD_Arm, Mean_Arm-0.75SD_Arm] |
| | Arm_bs | [Mean_Arm-1.5SD_Arm, Mean_Arm-0.75SD_Arm, Mean_Arm] |
| | Arm_s | [Mean_Arm-0.75SD_Arm, Mean_Arm, Mean_Arm+0.75SD_Arm] |
| | Arm_as | [Mean_Arm, Mean_Arm+0.75SD_Arm, Mean_Arm+1.5SD_Arm] |
| | Arm_has | [Mean_Arm+0.75SD_Arm, Mean_Arm+1.5SD_Arm, Mean_Arm+2.25SD_Arm] |
| Leg | Leg_hbs | [Mean_Leg-2.25SD_Leg, Mean_Leg-1.5SD_Leg, Mean_Leg-0.75SD_Leg] |
| | Leg_bs | [Mean_Leg-1.5SD_Leg, Mean_Leg-0.75SD_Leg, Mean_Leg] |
| | Leg_s | [Mean_Leg-0.75SD_Leg, Mean_Leg, Mean_Leg+0.75SD_Leg] |
| | Leg_as | [Mean_Leg, Mean_Leg+0.75SD_Leg, Mean_Leg+1.5SD_Leg] |
| | Leg_has | [Mean_Leg+0.75SD_Leg, Mean_Leg+1.5SD_Leg, Mean_Leg+2.25SD_Leg] |
| Trunk | Trunk_hbs | [Mean_Trunk-2.25SD_Trunk, Mean_Trunk-1.5SD_Trunk, Mean_Trunk-0.75SD_Trunk] |
| | Trunk_bs | [Mean_Trunk-1.5SD_Trunk, Mean_Trunk-0.75SD_Trunk, Mean_Trunk] |
| | Trunk_s | [Mean_Trunk-0.75SD_Trunk, Mean_Trunk, Mean_Trunk+0.75SD_Trunk] |
| | Trunk_as | [Mean_Trunk, Mean_Trunk+0.75SD_Trunk, Mean_Trunk+1.5SD_Trunk] |
| | Trunk_has | [Mean_Trunk+0.75SD_Trunk, Mean_Trunk+1.5SD_Trunk, Mean_Trunk+2.25SD_Trunk] |

TABLE II
CRISP INPUT VARIABLES FOR THE WORKOUT PROGRAM DESIGN UNIT

| Crisp Variable | Possible Values |
|---|---|
| Sex | Male/female |
| Weight | Real number |
| Height | Real number |
| Preference | Power lifting/core workouts/overall fitness |
| Schedule Template | (1,0,0,0,0,0,0), (1,0,0,0,1,0,0) (1,0,1,0,0,1,0), (1,0,1,0,1,1,0) (1,0,1,1,0,1,1), (1,1,1,1,1,1,0) |

fitness' programs set the first priority on the body-weighted exercises. The information on the types of exercises helps balance the workout programs. This is achieved by allocating different body part exercises in a day and the same body part exercises in different days. Then, overall parts of the body will be evenly exercised in a day. Finally the time constraint allows the design of a practicable program. How good the workout program is matters but if the user could practice the program is more essential. By keeping the time constraint set by the user, the system could design an executable workout program.

Algorithm 1 describes the pseudo code for the implementation of the scheduling layer. The layer manipulates the list of exercises and the empty timetable from the workout extraction layer. For checking the time constraint, a variable named 'time' is used. The list of exercises passes through ScoreEvaluation function. The function reorders the exercises according to the priority set by the user. Inclusion of running in the list means that running should be done before any workout. If the list contains running, the layer sets running as the first exercise of the working days.

After the initialization process, the scheduling algorithm starts to allocate exercises in the list into the time table. While inserting exercises into the time table, the algorithm checks various constraints. The first one is the time constraints. If the available time set by the user is over, then the algorithm stops putting exercises. Other constraints are related to exercise methodologies. For example, it is recommended not to conduct squat and deadlift on the same day. These constraints originate from the expert knowledge. Schwarzenegger's work details such rules [14].

Completion of exercise arrangement leads to the finalization

TABLE III
TYPES OF EXERCISES

| Name | Part | Classification |
|---|---|---|
| Running | Whole Body | Aerobic/Compound Joint/Body-weighted |
| Squat | Lower Body | Anaerobic/Compound Joint/Weighted or Body-weighted |
| Deadlift | Lower Body | Anaerobic/Compound Joint/Weighted |
| Power Clean | Upper Body | Anaerobic/Compound Joint/Weighted |
| Barbel Row | Upper Body | Anaerobic/Compound Joint/Weighted |
| Push Press | Upper Body | Anaerobic/Compound Joint/Weighted |
| Bench Press | Upper Body | Anaerobic/Compound Joint/Weighted |
| Pull Over | Upper Body | Anaerobic/Compound Joint/Weighted |
| Plank | Whole Body | Anaerobic/Compound Joint/Core |
| Back Bridge | Whole Body | Anaerobic/Compound Joint/Core |
| Butterfly | Whole Body | Anaerobic/Compound Joint/Core |
| Hindu Push Up | Whole Body | Anaerobic/Compound Joint/Core |
| Bicycle | Whole Body | Anaerobic/Compound Joint/Core |
| Lunge | Lower Body | Anaerobic/Compound Joint/Body-weighted or Weighted |
| Leg Raise | Lower Body | Anaerobic/Compound Joint/Body-weighted |
| Stepper | Lower Body | Anaerobic/Compound Joint/Body-weighted |
| Crunch | Upper Body | Anaerobic/Compound Joint/Body-weighted |
| Push Up | Upper Body | Anaerobic/Compound Joint/Body-weighted |
| Chin Up | Upper Body | Anaerobic/Compound Joint/Body-weighted or Weighted |
| Dips | Upper Body | Anaerobic/Compound Joint/Body-weighted or Weighted |

TABLE IV
CONTROL FACTORS AND THEIR VALUES

| Control Factor | Possible Values |
|---|---|
| Body Type | Thin, standard, or overweight |
| Preference | Power lifting, core workout, or overall fitness |
| Available Time | 30, 60, or 90 minutes |
| Available Day | 2, 3, or 5 days |

step. This step adds the information on how many sets and repetitions in a set the user should practice. This information is also brought from the previous layer and part of the crisp variables contain this information: $Num\_Set$, $Num\_Rep$, $Run\_Time$, and $Run\_Speed$. These variables are reflected in the final time table.

## IV. EXPERIMENT

To verify the performance of the proposed fuzzy expert system that designs a workout program, we conducted experiments under various environments. This section firstly describes the experiment setup and then discusses the experiment results.

### A. Experiment Setup

*1) Data set:* For the performance evaluation, we tested the proposed system with distinctive data sets. Body type, preference, and available time were varied. Each possible variation is described in Table 4. These variations can generate $3^4 = 81$ types of data sets. We selected the middle points of each fuzzy number and the Gaussian noise was added for the generation of the data sets. For instance, the weight of standard body type with height of 180.0 cm was set to 72.0 kg at first and the Gaussian noise was added. After the production of data sets, ten among the full data sets were randomly chosen and used for the verification.

*2) Evaluation of the results:* After putting the test data set into the proposed system, we evaluated the design products. The evaluation of the produced workout programs entails subtlety because there is no standard guideline for assessing a workout program. However, one can easily distinguish between an acceptable workout program from an unacceptable workout program by looking at if the preference is reflected and the constraints are met. We evaluated our system based on binary rejection ratio using this information. After the system had generated a workout program, we inspected it with the consideration of user preference and the constraints. Then, we decided whether to accept the program or reject it. The performance was calculated using the following equation:

$$Binary\_Rejection\_Ratio = \frac{Rejected}{Accepted + Rejected}, \quad (1)$$

where $Accepted$ is the number of acceptances and $Rejected$ is the number of rejections.

In the following sub-section, we report the test results and the analysis of the results.

### B. Results and Analysis

Table 5 shows the test sets and the corresponding results. The test data represents the fuzzy numbers of the fuzzy variables. The four components of the test data are body type, preference, available time per day, and available day per week, respectively. The expert system successfully generated workout programs according to the user input. However, a few of them showed unexpected results. The fifth result and the ninth result could not be accepted. In the fifth test data, the Day 4 program suggests two similar upper body exercises in one day: Push up and Hindu push up. This does not satisfy the constraint imposed by the constraint check function. The day 3 program of the ninth test data lays power clean ahead of squat. However, squat in general precedes power clean. Although

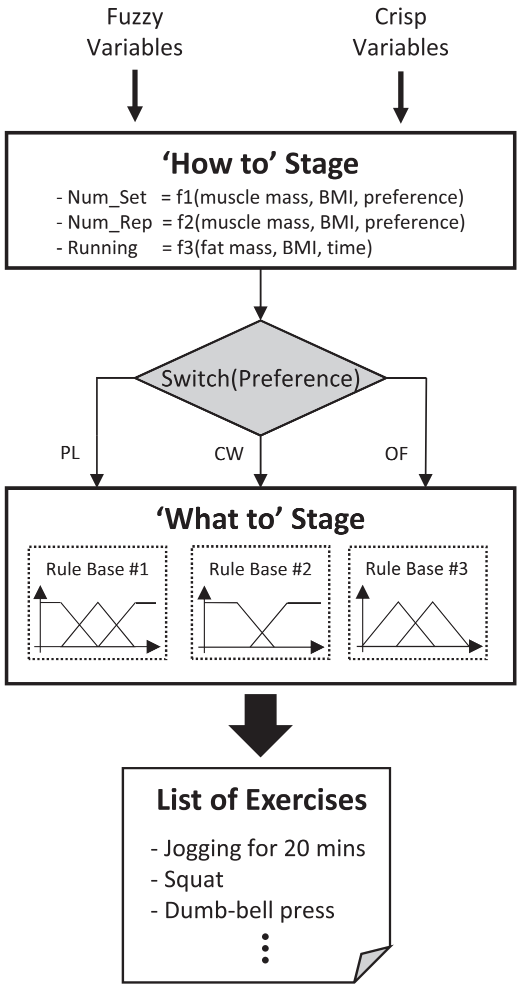


Fig. 2. The flow chart of the workout extraction algorithm. The algorithm receives fuzzy and crisp variables from the previous unit. Then, the algorithm how to exercise based on the user information. It determines the intensity of the workout program. The following stage selects best exercises for the user. A list of exercises comes out as a result.

**Algorithm 1** Scheduling Algorithm

**Input**: A list of exercises (L) and an empty time table (T)
**Output**: A completed time table

```
# initialization

time := 0
L :=ScoreEvaluation(L)

if L(1) == running then
    for i = 1 to t do
        T(i, 1) := running
    end for
    L(1 : l − 1) := L(2 : l)
    time += time(running) ∗ t
end if


# Scheduling process

i := 1
j := 1

while time < TotalTime do
    if i==t then
        i := 1
    end if
    ConstraintCheck(T(i),L(j))
    time+=time(L(j))
    i+=1
    j+=1
    if j==size(L) then
        break
    end if
end while
```

these two sets did not fully satisfy the constraints, eight out of ten data sets were acceptable.

The eighth test set requires a close look. Although the user had asked for a core workout program, the system produced a jogging program. This happened because the user's BMI was above the average. In this kind of cases, the system does not just accept the user's request but recommends a proper program. For this user, all the programs include a jogging program to help the user control the weight.

The system informs a user how much to workout as well. The running speed was jogging speed as mentioned above. If the user's BMI had been highly above standard, the running speed would have been a walking level. For the individual with BMI below standard, the system suggests fifteen sets of fifteen repetitions. This number is generally accepted intensity for people with BMI below standard [14]. On the other hand, people with BMI above standard received seven sets of seven repetitions. Since these people have heavier muscle mass, they could exercise with heavier weight.

The resultant binary rejection ratio is 0.8. Taking the fact that this is a pilot study of designing a fuzzy expert system for designing a workout program into account, the performance is reasonable. In the future research, diverse cases should be inspected after tuning the parameters and complementing the system functions.

## V. Discussion

In this paper, we presented a novel fuzzy expert system for designing workout programs based on fuzzy inference. The proposed expert system receives user's physical information and user's preference on exercise style as inputs. Then, the system produces a customized workout program for the user. Although the new system successfully generates user-oriented workout programs, there is room for improvement.

TABLE V
EXPERIMENT RESULTS

| Test Data | Produced Workout Program |
|---|---|
| 1. (BMI_bs, PL, 30, 3) | Day 1: (Squat), Day 2:(Deadlift), Day 3: (Power Clean) |
| 2. (BMI_bs, PL, 60, 2) | Day 1: (Squat, Power Clean), Day 2: (Deadlift, Barbel Row) |
| 3. (BMI_bs, CW, 60, 3) | Day 1: (Plank, Hindu Push Up), Day 2: (Back Bridge, Bicycle), Day 3: (Butterfly, Lunge) |
| 4. (BMI_s, OF, 90, 2) | Day 1: (Plank, Lunge, Crunch), Day 2: (Back Bridge, Leg Raise, Push Up) |
| 5. (BMI_s, CW, 60, 5) | Day 1: (Plank, Lunge), Day 2: (Back Bridge, Crunch), Day 3: (Butterfly, Leg Raise), Day 4: (Hindu Push Up, Push Up) Day 5: (Bicycle, Stepper) |
| 6. (BMI_s, CW, 60, 2) | Day 1: (Plank, Butterfly), Day 2: (Back Bridge, Hindu Push Up) |
| 7. (BMI_as, PL, 60, 3) | Day 1: (Jogging, Squat), Day 2: (Jogging, Deadlift), Day 3: (Jogging, Power Clean) |
| 8. (BMI_as, CW, 30, 5) | Day 1: (Jogging), Day 2: (Jogging), Day 3: (Jogging), Day 4: (Jogging), Day 5: (Jogging) |
| 9. (BMI_as, OF, 90, 3) | Day 1: (Jogging, Squat, Barbel Row), Day 2: (Jogging, Deadlift, Push Press), Day 3: (Jogging, Power Clean, Squat) |
| 10. (BMI_as, OF, 90, 2) | Day 1: (Jogging, Squat, Power Clean), Day 2: (Jogging, Deadlift, Barbel Row) |

Firstly, the system should include more expert knowledge sources regarding workout programs. Since the current system only reflects few sources of expert knowledge, the system can generate a limited number of types of workout programs. Thus, the present system cannot meet the user demands to the full extent. It is necessary to supplement the system with additional expert knowledge sources to satisfy user demands completely. Specifically, the additional sources would enhance the rule base of the workout extraction layer of the system and other types of exercises and workout programs would appear as a result.

A database system for storing numerous types of exercises extracted from new expert knowledge sources is the next concern. An ontology frame could be utilized for implementing the database system. One suitable candidate among a number of ontology models is fuzzy ontology. Since one exercise can be categorized in multiple groups, fuzzy ontology which expresses vagueness in an elaborate way is expected to store the data in the desired way. Squat, for example, could be categorized as a leg exercise and a whole-body exercise at the same time. Fuzzy ontology which allows inclusion in multiple categories handles this issue precisely.

Furthermore, the system could reflect diverse user preferences. The current system takes only three types of user preferences into consideration. Users might want to use combinations of current preferences or other types of preferences such as a weight control program and a one-specific-body-part intensive program. Enabling the system to consider new types of user preferences entails development of a new weight factor calculation algorithm. The new weight factor would modify the inputs to the scoring functions to meet the user demand on the workout program.

The future research could extend the system so that the system could utilize personal wearable devices. Integration of personal wearable devices into the proposed system enables the system to track when and where the users are working on the workout programs designed for them. By taking a close look at how users are following the workout program, the system could give other types of feedback to users. When the system detects that a user gets tired and does not follow the workout program regularly, the system could encourage the user to finish the workout program. Moreover, the system can manage users' health for a long-term period in a more effective way. The system could accumulate the user data and then extract the user preference and characteristics. The system could use these data for designing a customized workout program.

Last but not least, the proposed system benefits from a corporate synergy with the above-mentioned further works completed altogether. Adding various sources of workout planning theories to the system and extending the system to include wearable devices would diversify the services the expert system provides. For an instance, the big data the system accumulates facilitates the development of direct workout design algorithm which needs not accept user's preference as an input. By analyzing the relationship between body structure and the preferred workout plans, the system could recommend workout programs to users.

## VI. CONCLUSION

In this paper, we proposed a fuzzy expert system that produces a workout plan reflecting user's body condition, preference, and available time. The fuzzy expert system operates on the basis of fuzzy reasoning to deal with the vagueness that exists in the information a user inputs. The system consists of twp main units: user data preprocessing unit and the workout program design unit consisting of workout extraction layer and scheduling layer. Experiment results verified the effectiveness of the proposed fuzzy expert system. User preferences were reflected in the exercise plan and the workout programs satisfied given constraints. The future research includes the extension of the system to meet various user demands and to reflect a number of expert knowledge sources.

## ACKNOWLEDGMENT

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