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Design and Construction of an Automatic Body Weighing Scale for Classification of Pencak Silat Athlete Classes Using the Decision Tree Method

Rancang Bangun Timbang Badan Otomatis Untuk Klasifikasi Kelas Atlet Pencak Silat Menggunakan Metode *Decision Tree*

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Abstract _ *The current technological development is increasingly massive so that it has the opportunity to create innovation in the field of pencak silat. The weighing process is generally done manually relying on independent weighing tools that have not implemented an automatic classification system to check validity before competing. In addition, the recording is not integrated with the website . This has the potential to trigger misclassification not in the proper class and difficulty for officers in recording. Therefore, this study was conducted to design a weighing tool for class classification of pencak silat athletes aged pre -adolescent to adult automatically integrated with the website while providing ideal body information according to Body Mass Index (BMI). Relevant decision making is applied for athlete class classification, namely the decision tree method because the required attributes are met to create a decision tree. The working principle of the tool uses load cell sensor input to measure weight and ToF (time of flight) sensor to measure height. The results of weight measurements are used for class classification and combined with height to calculate BMI. The accuracy level of the load cell sensor with an average error percentage of 0.81% and an average success percentage of 99.19%. Meanwhile, the accuracy level of the ToF (time of flight) sensor has an average error percentage of 1.52% and an average success percentage of 98.48%.*

Keywords: *ESP32, Load cell sensor, ToF sensor, Decision Tree method, Website.*

Abstract_ Perkembangan teknologi saat ini semakin masif sehingga berpeluang untuk menciptakan inovasi dalam bidang pencak silat. Proses timbang berat badan umumnya dilakukan secara manual mengandalkan alat timbang independen yang belum menerapkan sistem klasifikasi otomatis untuk mengecek keabsahan sebelum bertanding. Selain itu pencatatannya belum terintegrasi dengan website. Hal ini berpotensi menjadi pemicu kesalahan klasifikasi tidak pada kelas yang seharusnya serta kesulitan bagi petugas dalam pencatatan. Maka penelitian ini dilakukan untuk merancang alat timbang berat badan untuk klasifikasi kelas atlet pencak silat usia pra-remaja sampai dewasa secara otomatis terintegrasi dengan website sekaligus memberikan informasi badan ideal sesuai Body Mass Index (BMI). Pengambilan keputusan yang relevan diterapkan untuk klasifikasi kelas atlet yaitu metode decision tree karena atribut yang dibutuhkan terpenuhi untuk membuat pohon keputusan. Prinsip kerja alat menggunakan input sensor load cell untuk mengukur berat badan dan sensor ToF (time of flight) untuk mengukur tinggi badan. Hasil pengukuran berat digunakan untuk klasifikasi kelas dan dikombinasikan dengan tinggi badan untuk menghitung BMI. Tingkat akurasi sensor load cell dengan rata-rata persentase error sebesar 0.81% dan rata-rata persentase keberhasilan 99.19%. Sedangkan tingkat akurasi sensor ToF (time of flight) dengan rata-rata persentase error 1.52% dan rata-rata persentase keberhasilan 98.48%.

Keywords: ESP32, *Load cell sensor* , ToF sensor , *Decision tree method* , *Website* .

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I. INTRODUCTION

Classification of pencak silat matches according to age and gender for all categories consists of early age 2 for boys and girls aged 8 to 11 years, pre-teen age matches for boys and girls aged 11 to 14 years and youth age matches for boys and girls, aged 14 to 17 years[1]. Athletes have a very crucial role in maintaining consistent body weight to be appropriate. In addition to the role of athletes, for preventive measures to deal with fluctuations in body weight, checks are usually carried out periodically by silat athlete trainers before the match or training center (TC)[2]. The last weigh-in is carried out 1 hour before the match starts then the weigh-in is only carried out once/; and witnessed by officials from both teams, referees, judges and weigh-ins who have been appointed by the technical delegation (TD)[3].

The progress of this research applies the decision tree method for classifying pencak silat athlete classes and includes BMI condition status, while previous research still used the z- score and rule base system method with children as the target object to examine nutritional conditions[4][5][6].

II. METHOD

2.1 Identification of problems

There are still weaknesses in determining athlete class classification using conventional weighing equipment in championships, such as manual methods such as using conventional scales and tables to verify the validity of athlete registration. Therefore, a decision tree method is needed to automatically classify pencak silat athletes based on their weight.

2.2 Literature Review

This research began with a literature review of journals, books, theories, agency websites, and previous research. The review served to understand the concept of the decision tree method and its application to automatic athlete class classification.

2.3 System Block Diagram

First, this system collects object data through sensors. Measurement of object height using a ToF (time of flight) sensor , which emits waves and recaptures the reflected waves on the reflecting plane, namely at the highest point of an object. Load cell sensor measurements for body weight with a maximum capacity of 200 kg are carried out by connecting the load cell sensor to the ADS1115 module. This module functions to amplify the output signal from the load cell sensor and convert data from analog to digital form. The data output from the ADS1115 module is then sent by the microcontroller to be processed by ESP32 and sent to the web. The data received by the microcontroller will be analyzed to determine the athlete's category and ideal weight status based on BMI, after which the results will be stored. Information that will be presented on the website includes the athlete's name, gender, class classification, BMI status, measurement history, and relevant graphs. This website will allow managers or athlete officials to find out information about the results of each athlete's weight and height measurements during the championship.

2.4 Hardware Design

Hardware design includes aspects such as mechanical design, electronic circuits, schematics, and PCBs.

Figure 1. Design of a weighing scale

Figure 2. Wiring Component

Information:
1. ESP32
2. ToF (Time of Flight) Sensor
3. Component Box
4. 200Kg Load Cell Sensor
5. ESP32 Devkit-V1 Module
6. LM2596
7. ADS1115 Module
8. Buzzer BD139
9. Load Cell Transmitter JY-S60

2.4.1 ESP32 microcontroller

The ESP32 series utilizes the Tensilica Xtensa LX6 microprocessor available in dual-core and single-core variants. In addition, the device includes an integrated antenna switch, power amplifier, low-noise receiver amplifier, filter, and food energy management module[7]. Its ability to integrate Wi-Fi and Bluetooth supports the development of systems such as smart surveillance, where the ESP32 is utilized for video acquisition and data transmission over Wi-Fi[8][9].

2.4.2 *Load Cell* Sensor

A load cell sensor is a device designed to measure the pressure or weight of a load. The working principle of a load cell sensor focuses on measuring the pressure applied to the sensor. When a load is placed on the load cell sensor, the resulting pressure will change the electrical signal, which can then be measured and interpreted as the weight of the load[10][11].

2.4.3 ADS1115 Module

The ADS1115 is a 16-bit analog-to-digital converter. The ADS1115 features a programmable gain amplifier, offers low noise, a precision delta-sigma ADC, and an internal oscillator[12].

2.4.4 ToF (Time of Flight) Sensor

Time-of-Flight (ToF) is a method used to measure the distance between a sensor and an object. ToF sensors are able to capture distance by measuring the travel time of the transmitted signal[13].

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2.4.5 Load cell Transmitter JY-S60

Load cell transmitter is used for signal conditioning from load brake, load bridge, weighing sensor or load cell module. This transmitter transmits and converts the load signal into standard 4-20mA dc current and 0-5V 0-10V voltage and its output can be adjusted via potentiometer, and the power supply is 12-24VDC.

2.4.6 *Website*

A web server is software that functions to provide data-based services and is responsible for receiving requests from clients, which are generally web browsers such as Mozilla Firefox or Google Chrome, via the HTTP or HTTPS protocol. *Servers* or *web servers* have an important role in transferring files requested by users, using established communication protocols. Requested web pages can include various file formats, including text, video, images, and other file types[14][15].

2.5 *Software* Design

1. **Admin Login**

admin login page is used to access the automated weighing scale. *Admins* who already have a registered account can *log in directly* by entering their *email address* and *password* .

2. **Athlete Data Input**

Used to enter pencak silat athlete data consisting of class, category, gender, athlete name and contingent.

Figure 3. Data input display

3. **Scale Display**

Figure 4. HMI display of the scales

2.6 Testing Scenario

The first is weight testing, namely the equipment is tested according to the weight variations of the athletes according to the class registered for the championship.

The second is a height test. The athlete stands on a weighing scale. The TOF sensor then measures the height based on the distance of the object.

2.7 Body Weight Measurement

Measurement can be understood as a process involving a comparison between a quantity and a measuring instrument that functions as a standard. The purpose of this process is to obtain a quantitative value of an object with a systematic approach through the use of a predetermined measuring instrument as a standard guideline[16]. In the world of sports, body weight is the main indicator for determining the category of athletes, especially in martial arts such as pencak silat and boxing[17].

2.8 Age Categories of Pencak Silat Athletes

The provisions regarding the age and weight of pencak silat athletes refer to letter No. 51/KH/VII/2023 concerning the circular of the regulations for pre-early childhood, early childhood 1, early childhood 2, pre-teen and teen competitions of the Indonesian Pencak Silat Association.

IPSI 2023. The age of the silat athletes participating in the competition must be proven through official documents such as an original birth certificate, diploma, or passport, or with a legalized photocopy. The age of the silat athletes must be in accordance with the participant's age category (pre-early childhood, early childhood I, early childhood II, pre-teen, and teenager) based on the applicable age in the month the competition begins (1).

Table 1. Of Age for Pencak Silat Matches

2.9 Class Classification Using Decision Tree

The automatic weighing scale decision-making for this class classification uses the decision tree method. A decision tre*e* is a decision-making method that contains training data attribute. Data is classified using a model. The calculation results are adjusted to the athlete's class at the time of registration in accordance with the regulations of the Indonesian Pencak Silat Association (IPSI).

III. RESULTS AND DISCUSSION

3.1 Classification of Athlete Classes Using the Decision Tree Method

Weight class decision making using a decision tree is as follows. Manual decision tree calculation using 15 data samples:

Table 2. Decision Tree Calculation Data

Table 3. Calculation of Entrophy and Gain

Calculating Entrophy:

$$Entrophy\ (S) = \sum_{i=1}^{n} -pi\ * \log 2\ pi$$

Keterangan:
S : Himpunan kasus
n : Jumlah partisi S
Pi : Proporsi dari Si (jumlah kasus partisi ke-1) terhadap S

Calculating BB Attribute Gain:

$$Gain = Entrophy\ (S)\ - \sum_{i=1}^{n} - \frac{|Si|}{|S|} - Entrophy(Si)$$

Keterangan:

S : Himpunan kasus
A : Atribut
n : Jumlah partisi atribut a
| Si | : Jumlah kasus pada partisi ke-1
| S | : Jumlah kasus dalam S

Figure 5. First node at age

Figure 6. Class classification of pre-teen categories

Figure 7. Class classification of youth categories

Figure 8. Class classification of adult categories

Table 4. Program Decision Tree

3.2 BMI sample of martial arts athletes

Table 5. Comparison of Calculation and System results

The calculation of respondent 1 in the table above is that the athlete is a class E pre-teen age category with BB (body weight): 42.6 Kg and TB (body height): 163 Cm. So the athlete class is in accordance with the weight range classification table, namely class E pre-teen category is above 42 Kg to 45 Kg.

Respondent 1:

$$BMI = \frac{\text{BB (kg)}}{\text{TB} \times \text{TB (m)}} = \frac{42.6}{1.63 \times 1.63\ (\text{m})} = 16$$

Based on the manual calculation above, it shows that respondent 1's BMI value is 16 kg/m ^{2}, categorized as "Thin". Based on the BMI value conditioning table, the value of 16 kg/m ^{2} falls within the BMI value range <18.5 kg/m ^{2}, categorized as "Thin". Based on the results of the manual calculation, it can be proven that the *decision tree method* in the system program created has results that are in accordance with the manual calculation.

Table 6. BMI Program

The table shows the comparison between manual calculations and the system created. The 67 sample data obtained have an average success rate of 99.19% for BB (body weight) measurements and an average success rate of 98.48% for TB (body height) measurements. Furthermore, the classification of athletes between AE athlete classes, from pre-teen to adult categories, with a weight range according to the provisions in table, is in accordance with the test results data in the table.

IV. CONCLUSION

This research successfully applied the decision tree method to an automated weighing scale to classify athletes based on their weight and determine their BMI. Load cell and time-of-flight (ToF) sensors enabled the capture of weight and height parameters based on the object.

Weight testing demonstrated that the robot was capable of measuring weight within the AE class range. However, the weight parameters sometimes experienced the largest differences from the comparison device.

In the height test, the scales experienced errors in taking height parameters due to the position of the object and also the influence of light reflection.

Overall, this system is in accordance with the research objectives, although it still requires improvements in system performance and accuracy.

V. ACKNOWLEDGEMENTS

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Tabel 1. Of age for pencak silat matches

No	Age Category (boys and girls)	Age Range (years)
1.	Pre-Early Childhood	≤ 5
2.	Early Childhood 1	>5 – 8
3.	Early Childhood 2	>8 – 11
4.	Pre-teen	>11 – 14
5.	Teenager	>14 – 17
6.	Mature	> 17

Tabel 2. Decision tree calculation data

NO	BB	AGE	CLASS
1	35.7	PRE-TEEN	B
2	34.9	PRE-TEEN	B
3	39.5	PRE-TEEN	C
4	41.7	PRE-TEEN	D
5	43.9	PRE-TEEN	E
6	41.2	TEENAGER	A
7	46.6	TEENAGER	B
8	51.1	TEENAGER	C
9	54.3	TEENAGER	D
10	61.3	TEENAGER	E
11	48.1	MATURE	A
12	54.7	MATURE	B
13	58.3	MATURE	C
14	62.7	MATURE	D
15	66.4	MATURE	E

Tabel 3. Calculation of entrophy and gain

		JUMLAH (S)	A (Si)	B (Si)	C (Si)	D (Si)	E (Si)	ENTROPHY	GAIN
TOTAL		15	2	4	3	3	3	2.28924643	
BB									0
	34.9-66.4	15	2	4	3	3	3	2.28924643	
USIA					\				0.100651667
	PRA-REMAJA	5	0	2	1	1	1	1.92192809	
	TEENAGER	5	1	1	1	1	1	2.32192809	
	MATURE	5	1	1	1	1	1	2.32192809	

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Tabel 4. Program decision tree

No	Program *Decision Tree*
1	else if (usia == "PRA REMAJA") {
2	if (kls == "A") return "30 - 33 kg";
3	else if (kls == "B") return "34 - 36 kg";
4	else if (kls == "C") return "37 - 39 kg";
5	else if (kls == "D") return "40 - 42 kg";
6	else if (kls == "E") return "43 - 45 kg";
7	else if (usia == "REMAJA") {
8	if (kls == "A") return "39 - 43 kg";
9	else if (kls == "B") return "44 - 47 kg";
10	else if (kls == "C") return "48 - 51 kg";
11	else if (kls == "D") return "52 - 55 kg";
12	else if (kls == "E") return "56 - 59 kg";
13	else if (usia == "DEWASA") {
14	if (kls == "A") return "45 - 50 kg";
15	else if (kls == "B") return "51 - 55 kg";
16	else if (kls == "C") return "56 - 60 kg";
17	else if (kls == "D") return "61 - 65 kg";
18	else if (kls == "E") return "66 - 70 kg";

Tabel 5. Comparison of calculation and system results

No	BMI Program
1	if (hasil < 18.50) return "Kurus";
2	else if (hasil < 25) return "Ideal";
3	else if (hasil < 30) return "Gemuk";
4	Else return "Obesitas";

Table 6. BMI rogram

No	Respondent	BMI Data		Description
		BB (Kg)	TB (Cm)	
1	Respondent 1	42.6	163	Skinny

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Figure 1. Design of a weighing scale

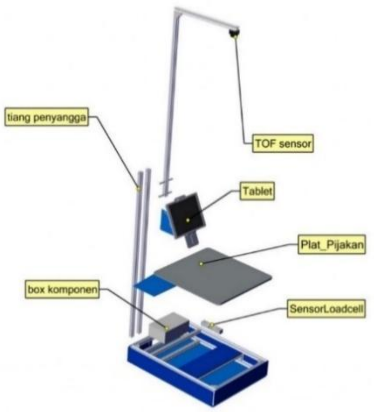

Figure 2. Wiring component

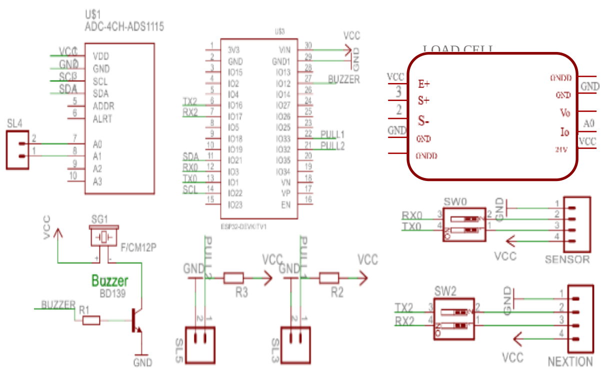

Figure 3. Data input display

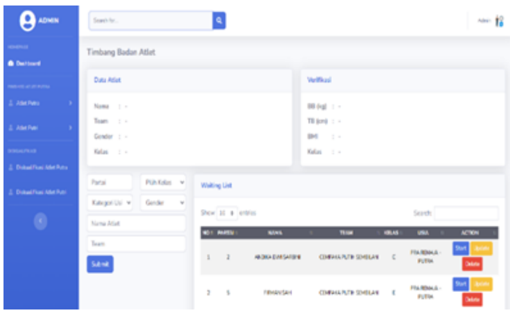

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Figure 4. HMI display of the scales

Figure 5. First node at age

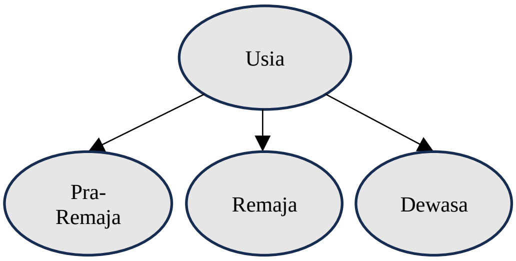

Figure 6. Class classification of pre-teen categories

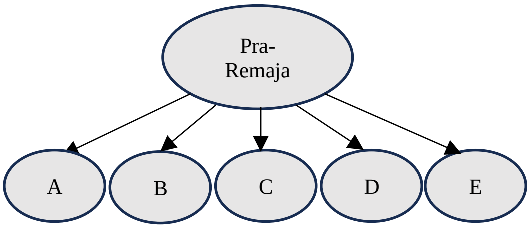

Figure 7. Class classification of youth categories

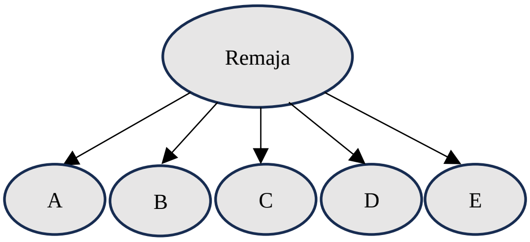

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Figure 8. Class classification of adult categories