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Tıp Eğitiminde CPR Mankenlerinin Yapay Zeka Sınıflandırıcı ile Dijital Dönüşümü

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Özet

Günümüzde Endüstri 4.0 ile başlayan dijital dönüşümün sağlık alanına yansıması, özellikle tıp fakültelerinde kurulan simülasyon merkezleri ile tıp eğitiminde de ivme kazanmıştır. Bu çalışmada, mekanik KardiyoPulmoner Resüsitasyon (CPR) ilk yardım eğitim mankeninin modüler olarak geliştirilen elektronik cihazlarla mesajlaşmasıyla elde edilen veriler toplanmıştır. Bu veriler ayrıca hem mobil cihazlar hem de masaüstü bilgisayarlar ile iletişim kurmalarını sağlamak için geliştirilen yazılım aracılığıyla işlenmekte ve Yapay Zeka (AI) algoritması ile gerçekleştirilen masaj etkinliğinin geçerliliği doğrulanmaktadır. Modüler elektronik kit, Kocaeli Üniversitesi Tıp Fakültesi Dekanlığı ve Acil Tıp Anabilim Dalı'nın desteğiyle Bilişim Anabilim Dalı Yapay Öğrenme Laboratuvarı'nda geliştirilmiştir. İdeal bir CPR masaj aralığı, dakikada 100-120 kez kompresyon ve yaklaşık 5-6 cm derinlikte göğse uygulanması olarak ifade edilir. Çalışmada yapılan kalp masajının geçerliliğini ve doğruluğunu belirlemek için, manken üzerine yerleştirilen sensörlerden toplanan verilere dayalı olarak bir AI sınıflandırıcısı ile Uzman Eğitmene ideal bir masajın yapılıp yapılmadığı konusunda geri bildirimde bulunulmuştur. Böylece mekanik manken sayısallaştırılarak daha etkin bir pratik eğitim uygulaması geliştirilecek ve sağlanacaktır.

Anahtar Kelimeler: *CPR Manken, YSA, Dijital Dönüşüm, Sınıflandırıcı, Tıp*

Digital Transformation of CPR Mannequins in Medical Education with Artificial Intelligence Classifier

Abstract

Today the reflection of digital transformation which started with Industry 4.0 in the field of health has also gained momentum in medical education with simulation centers established especially in medical schools. In this study, the data which attained by messaging mechanical Cardiopulmonary Resuscitation (CPR) first aid training manikin via electronic equipment developed modularly are collected. These data are also processed through the developed software which provides them to communicate with both mobile devices and desktop computers and the validity of the massage activity performed with an Artificial Intelligence (AI) algorithm is verified. The modular kit has been developed in the Informatics Department of Artificial Intelligence Laboratory with the support of Kocaeli University Faculty of

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Medicine Dean's Office and the Department of Emergency Medicine. An ideal CPR massage interval is expressed as compression of 100-120 times per minute and application to the chest at a depth of approximately 5-6 cm. In order to determine the validity and accuracy of the cardiac massage in the study, feedback is provided on whether an ideal massage was performed to the Observer Trainer with an AI classifier based on the data collected from the sensors placed on the manikin. Thus, by digitizing the mechanical mannequin, a more effective practical training application will be developed and provided.

Keywords*: CPR Manikin, ANN, Digital Transformation, Classifier, Medicine*

1 Introduction

Cardiac arrest, known as stopping heart is a health problem that needs to be addressed. According to researches, the mortality rate in cardiac arrest varies between 50 and 100 per 100,000 people, and the number of deaths from cardiac arrest in the United States alone varies between 150,000 and 450,000. First intervention is vital in cardiac arrest. When Cardiopulmonary Resuscitation (CPR) is performed by an untrained person, the rate of returning to life is between 3-8%, and when an educated person does it, this rate is between 16-22%. There are basically two components in CPR practice, ventilation and compression. Ventilation is the process that the patient is made keep on inhaling and exhaling [1]. This process is not vital in the first minutes of CPR, because there is enough oxygen in the patient's body in the first minutes. However, this is of vital importance in prolonged CPR applications. Compression is the pressure exerted on the heart over the rib cage to activate the patient's stopped heart. For a healthy CPR, compression should be done at the right depth and without interruption. CPR application that is not performed at the correct depth has no effect on the patient. The American Heart Association (AHA) has used the phrase "Push Hard and Fast" to emphasize the importance of depth in its CPR guidelines. According to this guideline, the correct depth is required to be kept between "38 and 51 mm", although it varies according to the body structure of the person. Uneducated people are unlikely to achieve these depth ratios. Continuous CPR application is an important factor for the patient. In the CPR manuals, 80-120 pressures per minute are recommended. Although it is an important cause of death, normal people have never witnessed a heart attack in their daily life. For this reason, they do not have the competence to interfere in cardiac arrest [2]. In this study, it is aimed that the trainees can reach the depths specified in the CPR guideline and increase the survival rate of the patients. In order to determine the validity and accuracy of the cardiac massage in the study, a feedback is provided on whether an ideal massage was performed to the Observer Trainer with an Artificial Neural Net (ANN) classifier based on the data collected from the sensors placed on the manikin. Thus, by digitizing the mechanical mannequin, a more effective practical training will be developed and provided.

2 General Information

Technological advances have rapidly shaped medical education over the past two decades, through innovations such as high-fidelity simulation, augmented reality, and web-based educational resources. As research in medical educational technology continues to advance, there is particular interest in the field of artificial intelligence [3]. In this section, general information about the CPR application system is given. CPR is the first aid method used in cases such as cardiac arrest or inability to breathe. CPR is short form of "cardiopulmonary resuscitation". Cardio heart refers to the pulmonary lung. Resuscitation is the intervention made to the patient whose breathing or blood circulation has stopped. CPR application that is not performed at the correct depth has no effect on the patient [4]. The part of this practice where no drugs or devices are used is called "basic life support" [5]. CPR is all of the methods that should be applied for emergency cases where the heart and breathing suddenly stop. These practices are popularly known as heart massage and artificial respiration. If CPR is performed within four minutes in cardiac arrest or in the event of respiratory arrest, 6% of patients survive. For these reasons, CPR is the first aid method that should be done in a short time. Failure to perform CPR has a high rate in deaths due to cardiac arrest. Conscious CPR application increases patients' chances of holding on to life [4]. Cardiac arrest is a lack of blood circulation in the body due to heart failure. Symptoms of cardiac arrest include heart palpitations, nausea and vomiting, loss of consciousness, inability to take a pulse, zero blood pressure, abnormal breathing [5]. Fig. 1 shows the correct position of the CPR application, Fig. 2 shows the correct position of the CPR application on the mannequin with proper depth, and a standard CPR manikin is shown in Fig. 3.

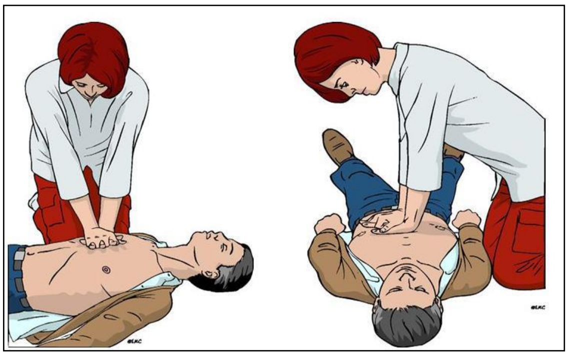

Fig. 1. CPR application correct position [5]

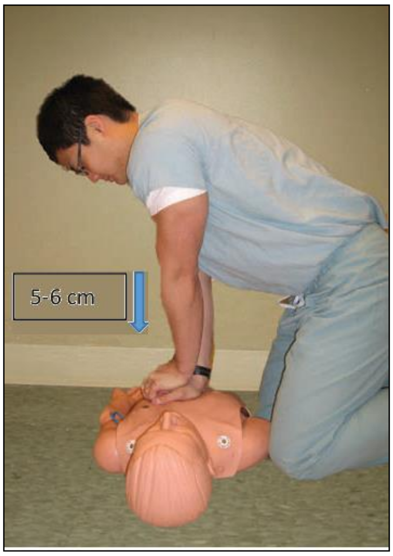

Fig. 2. The correct CPR implementation on a manikin [5]

Fig. 3. Standard CPR Manikin [6]

3 Material And Method

In this section, firstly, information about the materials used in the study work is given. Preparation and implementation of the experimental setup and computations with operating scenarios are described in the subsections. In the last section, the ANN classifier is presented.

3.1 System Elements

In this section, detailed information about the materials used in the study are given.

3.1.1 Microcontroller

Nodemcu Esp32-32S Wi-Fi card is used as microcontroller. It has a Wi-Fi module and many ports on it. It is frequently used in IoT (Internet of Things) projects thanks to the Wi-Fi (Wireless Connection Area) module it hosts. The Esp8266 module on the microcontroller receives the data from the weight sensor, it can connect to the internet and print it to the database and cloud system.

3.1.2 Weight sensor

A weight sensor converts force or load into an electronic signal. This electronic signal can be a current change, voltage change or frequency change depending on the structure of the sensor. The obtained signal is processed and provides the weight or force information. Since a maximum weight of 40 kg will be measured in the study, a 50 kg weight sensor loadcell has been used.

3.1.3 Weight sensor amplifier (HX711)

It is necessary to use a weight sensor amplifier to make sense of the data from weight sensors. The Hx711 gravity sensor amplifier shown in Fig. 6 was used in the study. In order to use the Hx711 module, the Hx711 library must be downloaded and installed beforehand.

3.2 Experimental Method

In this section, the preparation of the experimental setup is explained.

3.2.1 Preparation of test setup

Due to the structure of the weight sensor, its underside must be empty. For this reason, the part where the weight sensor is located in the experimental setup was placed in a slot to be left open. It is fixed to the experimental setup so that the weight sensor does not move. The circuit is built on a perforated copper plate for the integrated circuit board and Hx711 amplifier. In order to remove the microcontroller and Hx711 amplifier in case of a failure, female headers are soldered on the copper plate. Microcontroller and Hx711 amplifier pins are placed on these headers. Weight sensor, Hx711 amplifier and electronic circuit board have been connected in accordance with Fig. 4.

3.2.2 Calibration of weight sensor

Weight sensors need to be calibrated in order to measure the desired value precisely. Hx711 library program [7] is loaded on electronic circuit board. In the Arduino IDE application, the data coming from the microcontroller is programmed to be read on the screen. By placing a material which weight is known on the weight sensor, the value of the variable named calibration factor has been changed until the weight value reaches the correct value [8].

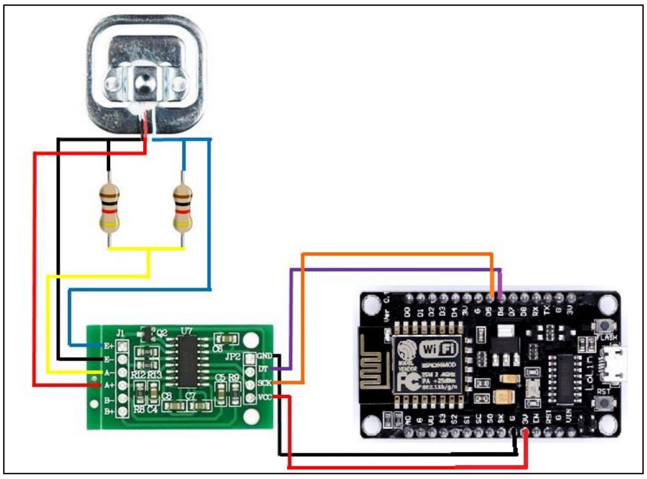

Fig. 4. Computer Environment Design of the Experiment

3.2.3 Client, Cloud, Rest App Design

Real-time monitoring and recording of sensor data on mannequins with WebSocket is planned. The client application will be provided to work in two different modes, online and offline [9]. If it is working in online mode, it saves the data which receives with the WebSocket on the mannequins to the cloud application with restful. If it is working in offline mode, the data can be recorded in the database on the client application, and also the data can be recorded in the cloud application when switched to online mode. It is aimed to manage the data of the client application that can work on different hardware from a single point. The design setup is shown in Fig. 6.

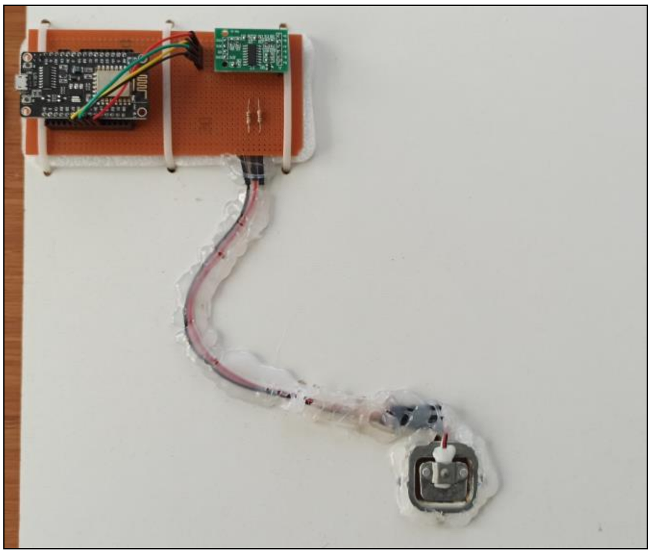

Fig. 5. Experimental Setup Design

3.3 Computations and Operating Scenarios

In this section computational issues and operating scenarios are described. In each subsection computer environment design of the experiment setup is explained for computing chest compressions, stage of data acquisition and operating scenarios.

3.3.1 Computing chest compressions

The number of compressions is as important as the depth of the pressure applied in the CPR application. Insufficient compressions count can lead to death of the patient. The American Heart Association has announced in its CPR guidelines that the compressions count should be the number of heartbeats of a normal person. A normal person's heart beats between 80 and 120 per minute [10]. It is desired that the CPR application performed should be at that speed. The values from the weight sensor were used to find the number of compressions in the study [11].

The collected values were analyzed using the peak value method. In the peak value method, in order to the value to be peak, it must be greater than the previous and next values. The electronic circuit board can read the weight data 11 times per second. Peak values were found by evaluating the received data according to the peak value method.

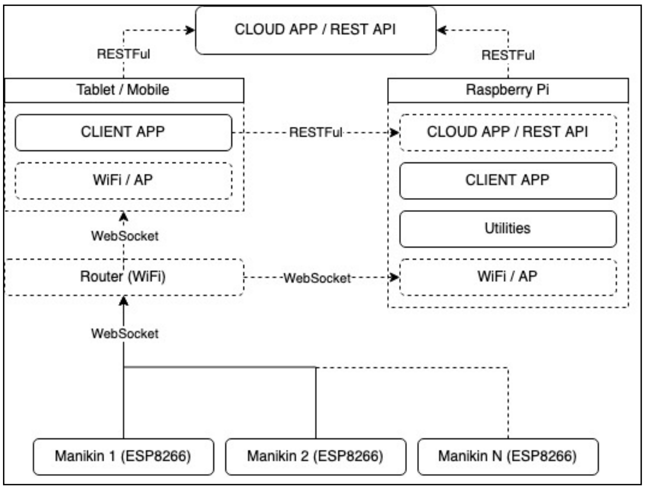

Fig. 6. Client, Cloud, Rest App Design

3.3.2 Data Acquisition

The gender, application order, number of tests, age, weight and height of the trainee to be applied are recorded. A data set is created for the ANN classifier by obtaining the heart massage data applied by the trainees over a period of one minute through the serial port. The data set includes trainee information, application time, massage time, applied weight values. Fig. 7 shows a sample of taken data. Fig. 8 shows the scheme of obtaining these data.

3.3.3 Operating Scenarios

In this section, the success scenario of the study and the absolute errors that may occur are explained. The main success scenario is the error-free scenario of the application and the desired ideal values are achieved. Information on gender, application order, number of tests, age, weight and height of the person to be applied were register before the application. Sample record (Male1_1.test_age_weight_height) is M1_1_35_80_183. By pressing the reset button in the application, the trainee administered CPR for one minute. At the same time the data are recorded in the data set.

	A	B	C	D	E	F	G
1	ID	Use Simpe Test Examples to test	Milis	Weight	Ax	Ay	Az
2	M14_1_46_79_174	14:26:18	2075	0	-4316	2408	16928
3		14:26:18	2174	0	-4420	2244	16144
4		14:26:18	2273	0	-4184	2888	17008
5		14:26:18	2373	0	-4588	3260	16536
6		14:26:18	2473	0	-4664	3384	16276
7		14:26:18	2572	0	-5032	2420	16480
8		14:26:18	2672	0	-4380	3528	17036
9		14:26:18	2771	1519	-5244	2120	16496
10		14:26:18	2871	3392	-7812	808	17096
11		14:26:18	2970	10327	-5872	1472	16356
12		14:26:19	3070	19744	-6176	296	16676
13		14:26:19	3170	21102	-5776	1028	16540
14		14:26:19	3269	13847	-6280	3164	16508
15		14:26:19	3369	3961	-4888	3772	15412
16		14:26:19	3468	0	-5776	1880	15684

Fig. 7. Sample Data

Fig. 8. An Experiment Instance

3.4 Artificial Neural Net Classifier

In order to determine the validity and accuracy of cardiac massage in the study, 1-minute test data were collected from 51 people. Approximately 1000 of data were read in each test process. Based on the data, feedback was provided on whether an ideal massage was given to the Observer Trainer with an ANN classifier. With the MATLAB® program, the identity data on each excel sheet was read and CPR data was created. The noise data occurring over 50 kg and below 5 kg have been removed. It was determined how many compressions each trainee made in 1 minute. It was also determined how many compressions were made between 25kg and 35kg, and it was scored by 100 points. 20% of the data is randomly allocated for testing and 80% for training. An artificial neural network with 10 neurons is used in a hidden layer with 5 inputs. In Fig. 9 ANN architecture can be seen. This architecture is trained for 1000 epochs and calculated for Mean Square Error (MSE) training data and is shown in Fig. 10. Then, the network was simulated with randomly selected test data and the estimation and target data of these test data were obtained as shown in Table 1. MSE for the test data was calculated as 1.7%. Successful practice above 90 points in Table 1 reveal that male trainees perform more successfully. When evaluating all the data, the information of the people with the best performance above 90 points is also shown in Table 2.

Table 1. Target and estimation scores of test data

Trainee Info.	Estimation	Target
1. 'M03_3_16_55_170'	67.0144	67.0000
2. 'M04_1_17_65_175'	**91.6418**	**91.5000**
3. 'M05_2_17_58_173'	**95.9573**	**96.0000**
4. 'F06_3_17_49_157'	58.7052	60.0000
5. 'F07_2_16_48_158'	49.4950	49.5000
6. 'M08_2_17_63_182'	**90.5126**	**90.5000**
7. 'F10_2_17_47_170'	59.9979	60.0000
8. 'M11_1_17_80_182'	36.5006	36.5000
9. 'M11_3_17_80_182'	57.9633	58.0000
10. 'M12_2_20_60_179'	62.4960	62.5000

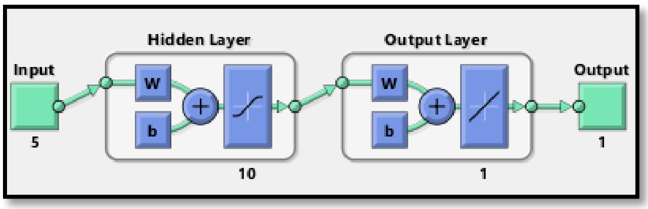

Fig. 9.Arthitecture of ANN

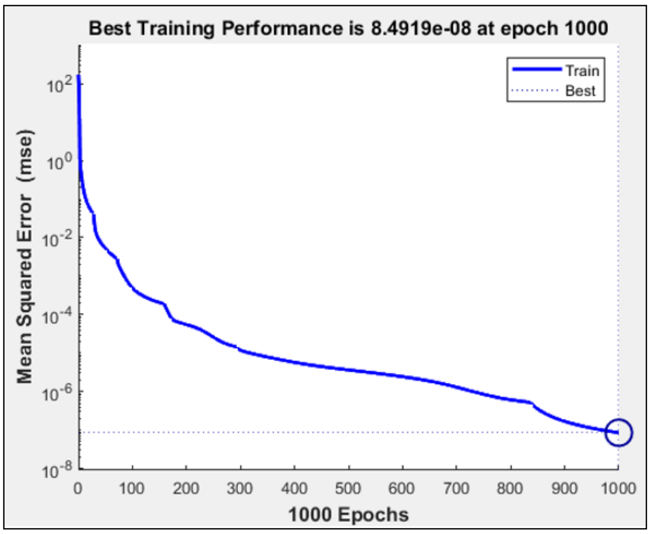

Fig. 10. MSE values during training

Table 2. Trainees' info for highest scores

Trainee Info.	Highest Scores
1. 'F02_2_16_45_165'	90.5000
2. 'F02_3_16_45_165'	94.5000
3. 'M03_1_16_55_170'	92.5000
4. 'M04_1_17_65_175'	91.5000
5. 'M04_2_17_65_175'	100.0000
6. 'M04_3_17_65_175'	100.0000
7. 'M05_2_17_58_173'	96.0000
8. 'M05_3_17_58_173'	100.0000
9. 'M08_1_17_63_182'	95.5000
10. 'M08_2_17_63_182'	90.5000
11. 'M16_1_47_87_182'	96.5000

4 Conclusion

In this study, it is aimed that an ANN classifier to support the trainees can reach the ideal CPR application. A modular sensor system is designed to collect the CPR data. The collected data were sent through Wi-Fi system and evaluated in the ANN classifier. In order to determine the validity and accuracy of the cardiac massage, a feedback is provided on whether an ideal massage was performed to the Observer Trainer with an ANN classifier. The test result of the recorded data show that all test results are classified correctly with 1.7% MSE value. As a result of digitizing the mechanical mannequin, a more effective practical training will be developed and provided. In the next stage, it is planned to assemble the system on the mechanical CPR mannequin and transfer the processed data to the cloud system.

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