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Location indicators of automated external defibrillator electrode patches using image processing techniques ☆

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ABSTRACT

A sudden cardiac arrest can lead to death if emergency treatment is unavailable. However, the proper use of an automated external defibrillator (AED) can save lives. This study is based on an image processing technology for automatically indicating the electrode patch locations of an AED. We use three strategies to achieve this goal: (1) Create a body proportional positing method (BPPM) to solve the problem of differing body shapes. (2) Apply three features: the center of the neck, the ends of the shoulder, and a calculation of the slope to accurately determine the correct electrode patch locations of the AED. Finally, (3) apply a standard deviation to compensate the calculated center points of the trained AED electrode patches. Simulation results demonstrate that our scheme is an effective and accurate method for indicating the locations of AED electrode patches.

1. Introduction

Accompanied by advanced medical techniques, the average human life expectancy has increased. However, cardiac disease is the cause of three out of every ten deaths. If the heart stops beating suddenly owing to the presence of cardiac disease, death will inevitably follow. However, an electric shock applied to a stopped heart can often allow the heart to resume beating. The correct and effective use of electric shock can therefore save human lives.

An automated external defibrillator (AED) is a popular tool used for applying an electric shock to the heart. According to an emergency medical treatment law in Taiwan [1], there are eight public places where AED equipment needs to be set up: along vital communication lines, in vehicles used for long distances, tourist resorts, schools and other large gathering places, leisure resorts, large shopping areas, areas of accommodation, and bathing places.

Hooman Samani and REongbo Zhu [2] proposed a robotic AED ambulance for emergency medical services. In their assessment, inaccessibility to emergency treatment after a sudden cardiac arrest could lead to death. Thus, treatment using an AED must be administered to the victim within a few minutes after a collapse. They designed and developed a robot for bringing an AED to a victim undergoing a cardiac arrest in a smart city.

Edmar et al. [3] proposed Matlab specifications as an analytical model for an AED, which are associated with a model-based engineering methodology through a descriptive model. This model allows us to analyze schemes for determining

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Fig. 1. Use of the electrode patches of an AED.

whether to apply a requested shock treatment, the circuit performance when obtaining the required voltage, safety of the energy generated for shock delivery, and features of the signals created at the output of the AED.

Radon et al. [4] proposed a collection of pediatric ECG data for the detection schemes of an AED. They focused on establishing a pediatric ECG reference dataset with pulse remarks for an assessment of AED arrhythmia detection schemes.

Han et al. [5] presented an AED framework that includes two crucial components with an elaborate design. One is the hardware system, and the other is the algorithm used for detecting the ventricular fibrillation. This system can discriminate ventricular fibrillation from other non-shockable rhythms applied through the measurement of the sample entropy. In addition, their algorithm can match a short data sequence analysis, and achieve a good balance between the detection time and accuracy. Fig. 1 shows the use of an electrode patch of an AED. The correct locations for the upper-right and lower-left electrode patches of the AED are indicated.

Several studies on AED and image applications can be found in [6–14]. In the present paper, we focus on developing a method using an image processing technology to automatically indicate the locations of the electrode patches of an AED. The remainder of this paper is organized as follows. Previous related studies are described in Section 2. The system algorithm is illustrated in Section 3. Empirical results are detailed in Section 4. Finally, Section 5 provides some concluding remarks regarding this research.

2. Related work

According to teaching materials developed by the Ministry of Health and Welfare of the Republic of China, suitable locations of an electrode patch of an AED are as follows: a distance three fingers wide from the upper portion of the nipple, and three fingers wide from beneath the right clavicle. However, it is important to find an algorithm suitable for each AED electrode patch location.

2.1. Body proportions positioning method

For determining the proper electrode patch locations of an AED, finding a method suitable for all body shapes, including overweight, thin, tall, and short, is a core task. After reviewing several studies, we found that the body proportions positioning method (BPPM) is an excellent way to achieve this goal. For people with wider shoulders, the left electrode patch and right electrode patch will require a wider scale. On the contrary, for thinner people, the distance between the electrode patches is proportionately narrower based on their shoulder width. Therefore, we used the scale theory to develop the BPPM and achieve the correct location of the left and right AED electrode patches.

Fig. 2 illustrates the BPPM, where the two end points of the shoulder are denoted as points a and b, respectively, the length between these points is expressed as w, and the center of the neck is indicated by v_0. In addition, v_1 is at the center of the abdomen, and the line segment connecting v_0 and v_1 is orthgonal to w. Moreover, the length of this line segment is equal to w and is denoted as h. However, the kernel points and the center of the electrode patch are indicated by c_{ru} and c_{lb}, which are right and left parts of the AED, respectively.

2.2. Mathematical model

For developing a location indicator of an AED electrode patch, the kernel work is to develop a canonical form suitable for different body types. Using the BPPM, we have to obtain the center point of the upper-right and lower-left AED electrode patches intuitively. In addition, offset data are necessary to compensate for errors produced by different body shapes. The details of the equation derivation are described as follows.

2.2.1. The center point of the upper-right electrode patch of an AED

For a canonical form of the AED electrode patches through the use of the BPPM, several subjects M are used to train the center point of the upper-right and lower-left electrode patches. These M subjects have different body shapes, including

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