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Validation of Agitated Patient Remote Monitoring Alarm System in the Intensive Care Unit

Ying-Li LEE[a,b,1], Ming-Chuan CHANG[a], Cheng-Li CHANG[a] and Wan-Yu CHI[a]
[a] *Nursing Department, Chi Mei Medical Center, Tainan City, Taiwan, ROC*
[b] *Department of Nursing, Chang Jung Christian University, Tainan City, Taiwan, ROC*

Abstract. The purpose of this research is to innovate and develop a vision-based remote monitoring alarm system for agitated patients to provide intensive care unit (ICU) nurses with action warnings for agitated patients during their busy work. After the system is completed, preliminary laboratory verification is carried out, and the results are 94.87% in sensitivity, 97.44% in specificity, and 96.15% in accuracy, which enhances the confidence of the follow-up system in clinical testing.

Keywords. Visual-based motion detection, agitation, motion analysis

1. Introduction

Most patients in the intensive care unit use multiple life-sustaining equipment. Health care professionals in the intensive care unit (ICU) often use sedative drugs or physical restraints to prevent patients from removing various life-sustaining tubes without warning, which would endanger their lives. Even under physical restraint, patients still try hard to remove the tubes that make them feel uncomfortable. This research aims to innovate and develop a vision-based remote monitoring alarm system for agitated patients to assist ICU nurses to monitor the movements of agitated patients during their busy work and to conduct laboratory verification of this system.

2. Approach

2.1. System Development

This research uses Microsoft Kinect V2 to recognize and track the patient's posture, and then uses computer game graphics to draw virtual patient images and movements, and design a vision-based motion detection system. The system can track and identify the position and direction information on the 25 joint points of the patient's bones in space. After obtaining the information, immediately compare the warning range that users can define by themselves. When the patient's postures appear in the preset various warning

[1] Corresponding Author, Ying-Li Lee, No. 901, Zhonghua Rd, Yongkang Dist., Tainan City 71004 Taiwan, ROC; E-mail: n930969@mail.chimei.org.tw.

ranges, different levels of noise can be emitted immediately to remind the nurses to adopt relevant care strategies.

2.2. Evaluation of System Reliability and Validity

In order to test whether the system can effectively achieve the identification and warning effect, this study simulated the beds in the intensive care unit in the laboratory for field tests. The researchers set a total of 13 actions, and each action needs to be tested separately at 3 different speeds and 2 different warning distances. There is a total of 78 sets of actions for the system validation.

2.3. Statistical Analysis

The collected data were analyzed by IBM SPSS version 22.0 for statistical validity.

3. Results

After the system is configured, virtual patient images and movements can be displayed on the system screen after patient motions are detected. When the patient moves to the preset range of various warnings, different levels of warning sounds can be issued immediately. The results of the laboratory simulations are shown in Table 1.

Table 1. Validation result of the experiments

Statistic	Value	95% CI
Sensitivity	94.87%	82.68-99.37%
Specificity	97.44%	86.52-99.94%
Positive Likelihood Ratio	37.00	5.34-256.47
Negative Likelihood Ratio	0.05	
Positive Predictive Value*	97.37%	84.22-99.61%
Negative Predictive Value*	95.00%	83.11-98.66%
Accuracy*	96.15%	89.17-99.20%

4. Conclusions

The advantages of this system include 24-hour continuous clinical care monitoring, assisting caregivers in monitoring agitated patients, reducing the dead angle created by manual monitoring, and enhancing patient safety. The software design uses computer game graphics to create virtual patient images and movements. The design takes into account patient safety, patient privacy, and clinical practicality, and is suitable for a wide range of applications, making it valuable for commercial use and promotion. Currently, we are filing an Invention Patent of the Republic of China (Patent Application No. 109122066). We will also keep improving and commercializing systems, conducting clinical trials, and implementing artificial intelligence designs.