Design of a Simulation Device to Test Electrogastrography (EGG) Systems

Paulo Cunha
Federal Institute of Alagoas, Brazil

Álvaro Alvares de Carvalho César Sobrinho
Federal University of Campina Grande, Brazil

Leandro Dias da Silva
Federal University of Alagoas, Brazil

Angelo Perkusich
Federal University of Campina Grande, Brazil

Jose Miranda
Paulista Júlio de Mesquita Filho State University, Brazil

INTRODUCTION

Home care service provides remote healthcare to patients. It has grown in the last years mainly in the treatment of elderly people. The remote monitoring of patients can improve quality during the healthcare. The home care service provides a similar healthcare assistance compared to the hospital environment. However, in the first one the treatment is performed at home. This can decrease the stress of patients, hospital infection, and other characteristic hospital problems. Remote monitoring enables caregivers to perform verifications of patients' clinical situation. One can implement it using alerts related to the occurrence of undesired events in real time. For example, it is possible to use mobile applications to monitor patients with Cardiovascular Diseases (CVD) using Electrocardiography (ECG) systems (Alamäki, Muhammad, Sorvoja, Matti, Ashraf & Oem, 2007). Electrogastrography (EGG) systems are other application examples used to monitor patients with gastric disorders such as gastroparesis (Komorowski, Pietraszek & Grzechca, 2012; Yin & Chen, 2013). The gastroparesis results in nausea, vomiting, early satiety and postprandial fullness. This can aggravate the clinical situation of patients leading to weight loss, malnutrition, and dehydration.

The main subjects in this work are surface EGG systems. Caregivers use EGG systems to acquire gastric myoelectric signals (slow waves) in order to provide diagnosis and treatment of gastric disorders. These systems have characteristics such as skin-electrodes impedance verification, signal filtering, signal amplification, and verification of occurrence of slow waves related to cycles per minute (cpm) (Sobrinho, Silva, Perkusich & Cunha, 2014). In this context, we are concerned about the safety and effectiveness of EGG systems. Malfunctioning can result in incorrect evaluations and consequently in life-threatening complications. Manufacturers usually perform tests and calibrations in this type of medical system using simulation devices to replace signals that should be acquired from patients. There are simulation devices available in the market to test and calibrate more popular systems such as ECG. For example, Chien (2007) propose an ECG simulator which generates two analog ECG signals with noises using three differential equations. Lynch (2015) presents an ECG simulator which uses a digitized image to generate two analog

ECG signals without noises. Finally, Das et al. (2012) describe an ECG simulator which generates two analog ECG signals with noises from the PHYSIONET ECG database. The generated signals represent normal or abnormal patients' conditions and they are composed of different noise levels. However, there is a lack of research on the development of less common systems such as EGG simulators.

We present in this chapter the design of an EGG simulation device. Manufacturers can use the device to perform tests related to the safety and effectiveness of EGG systems. Concepts, challenges and problems during the development of EGG systems are discussed by a literature review. We also propose some solutions to decrease development problems using the EGG simulator.

BACKGROUND

We introduce in this section concepts about the main subjects discussed in this chapter. More specifically, we present concepts related to the Electrogastrography (EGG) examination, EGG systems and Proteus Virtual System Modelling (VSM).

Electrogastrography

Physicians use the EGG examination to analyze the gastric myoelectrical activity of patients (Parkman, Hasler, Barnett & Eaker, 2003). The gastric myoelectrical activity is also named slow waves due to the low amplitude and frequency of the signal. These slow waves are generated from stomach pacemaker cells. The EGG is a non-invasive test used to record the slow waves by electrodes, such as the electrodes used in Electrocardiography (ECG) examinations. EGG electrodes are usually placed on the abdomen of patients in a specific lead configuration. The EGG signal is a 3 cycles per minute (cpm) sinusoid for healthy human. The EGG signal is composed of the slow waves and different noises. However, the results of EGG examinations must contain only the slow waves (Koch & Stern, 2004).

The EGG signal is usually analyzed in the frequency domain due to its sinusoid waveform using techniques such as the Fourier analysis. There are EGG waveform patterns that help the analysis of the patients' situation in the frequency domain. The categories of EGG rhythm are presented in Table 1. Categories include arrhythmia, bradygastria, normal rhythm, tachygastria, and respiratory rhythm. Arrhythmia occurs due to irregular gastric activity (no recurrent frequencies). Bradygastria occurs when the gastric activity presents recurrent frequencies slower than normal. The normal rhythm occurs when the predominant peaks are in the 2.4-3.6 range. Tachygastria occurs when the gastric activity presents recurrent frequencies greater than normal. Finally, respiratory rhythm occurs when the predominant peaks are in the 10-15 ranges. Besides, one must take into account changes in the EGG waveform related to

Table 1. The four EGG rhythm categories

EGG Wave Patterns (cpm)	Description
0	Arrhythmia
1-2.4	Bradygastria
2.4-3.6	Normal
3.6-9.9	Tachygastria
10-15	Duodenal/Respiratory rhythms

Related Content

The Use of AI-Supported Chatbot in Psychology
Kadir Uludag (2025). *Chatbots and Mental Healthcare in Psychology and Psychiatry (pp. 1-20).*
www.irma-international.org/chapter/the-use-of-ai-supported-chatbot-in-psychology/371637

Rethinking the Continuous Education and Training of Healthcare Professionals in the Context of Digital Technologies
Carlos Alberto da Silva, Rui Pedro Pereira Almeida, António Fernando Abrantes, Kevin Barros Azevedo, Bianca Vicente, Francisca Carvalheira, Eurico José Ribeiro Floresand Tatiana Mestre (2023). *Handbook of Research on Instructional Technologies in Health Education and Allied Disciplines (pp. 105-129).*
www.irma-international.org/chapter/rethinking-the-continuous-education-and-training-of-healthcare-professionals-in-the-context-of-digital-technologies/320376

Developing More Effective and Adaptive U.S. Governmental Healthcare Leaders
Amalisha Sabie Aridi (2022). *International Journal of Health Systems and Translational Medicine (pp. 1-25).*
www.irma-international.org/article/developing-more-effective-and-adaptive-us-governmental-healthcare-leaders/314579

Design Frameworks for Mobile Health Technology: A State-of-the-Art Review of Research From 2015-2021
Ke Zhangand Ayse Begum Aslan (2022). *International Journal of Health Systems and Translational Medicine (pp. 1-13).*
www.irma-international.org/article/design-frameworks-for-mobile-health-technology/302653

Refinement of Hypothesis Testing in Conjugation Tables of r(c Size on the Example of Testing New Forms of Treatment
Lidiya Filippovna Taenvatand Mikhail Mikhailovith Taenvat (2022). *International Journal of Health Systems and Translational Medicine (pp. 1-13).*
www.irma-international.org/article/refinement-of-hypothesis-testing-in-conjugation-tables-of-rc-size-on-the-example-of-testing-new-forms-of-treatment/306691