DESIGN OF A HUMAN MACHINE INTERFACE FOR TRAINING ACTIVITIES WITH PRODDERS

Roemi Fernández[*], Carlota Salinas[*], Héctor Montes[*, †], Javier Sarria[*], Manuel Armada[*]

Abstract

This paper presents the Human Machine Interface (HMI) that has been designed for improving the training activities of demining operations carried out with prodders. The proposed HMI will contribute in gathering, analysing, presenting and consolidating the information acquired with an intelligent feedback prodder that has been especially conceived for interacting with this application. The friendly graphic user interface will present the data received in an efficient format, maximizing the instructor's ability for monitoring, processing and assessing the trainee performance. The different components, features and functions of the HMI are described in detail through this document.

Introduction

Humanitarian demining is difficult and dangerous, as it requires the complete removal of all mines and the return of the cleared minefield to normal use [1-3]. Metal detectors and prodders are still the most important tools for humanitarian demining. Prodders are mainly used as complement to the metal detectors, so that once a possible target has been detected, the prodder permits to locate it in the terrain. Finding mines with a prodder involves pushing tool into the ground and relaying on tactile feedback to identify an obstruction that maybe a mine [4]. Prodding on antipersonnel mines is a major cause of demining accidents in some countries, especially where the soil is hard or rocky. Some studies [5] involving field measurements of the force exerted by the operators showed that deminers, and even senior training staff, had no real idea of the force they were using and consistently underestimated the force they were exerting by large amounts. To alleviate this situation, an intelligent prodder, which gives to the deminer information about the amount of force exerted and alerts him when the prodder's angle is approaching or exceeding a certain limit, has been designed and implemented. The emphasis in this article will be put on the description of the proposed HMI. The interface will be responsible of collecting the data acquired by the instrumented prodder, processing and analysing the measured performance variables, and presenting the essential information required during the training sessions. The rest of the paper is organised as follows. Section 2 briefly introduces the intelligent feedback prodder responsible for acquiring the performance data during the training sessions. Section 3 describes the screen components, links and functions of the HMI and finally, Section 4 summarises major conclusions.

Intelligent feedback prodder

The intelligent feedback prodder for training consists of a HMI, an instrumented prodder, a data acquisition module and an electronic module for signals conditioning. All basic parts of the instrumented prodder (sensors, a rod with a sharp spike, a handle and an extension) are separable with the ability of replacing different extensions in order to obtain different versions of the prodders, depending on the demining training needs. For the design of the instrumented prodder, two main types of sensors have been evaluated and selected: a load cell and an Inertial Measurement Unit (IMU). Table 1 and 2 summarise the main technical specifications of the selected compression load cell and the IMU, respectively.

The electronic module for signals conditioning is responsible of filtering and amplifying the force sensor output in order to meet the requirements of the next stage, in which the data acquisition module converts the resulting

[*] Centre for Automation and Robotics CAR CSIC-UPM. Agencia Estatal Consejo Superior de Investigaciones Científicas. Ctra. Campo Real Km 0,200 La Poveda, Arganda del Rey, 28500 Madrid, Spain. E-mails: {roemi.fernandez, carlota.salinas, hector.montes, javier.sarria, manuel.armada}@car.upm-csic.es

[†] Faculty of Electrical Engineering, Technological University of Panama, Panama City, Panama.

analog signal into a digital one for further processing. The sampling frequency was chosen to be 100 Hz for the IMU signals and 500Hz for the force signal.

Table 1. Main technical specifications of the compression load cell.

Parameters	Values
Thickness	3.81 mm
Diameter	25.4 mm
Non-linearity	± 1% FSO
Hysteresis	± 1% FSO
Deflection at "FS"	< 0.013 mm nom.
Thermal zero shift	± 2.5mV/50ºC
Thermal sensitivity shift	± 2.5%/50ºC
Operating temp.	(-40 to 120)ºC

Table 2. Technical specifications of the IMU.

Parameters	Orientation Performance	Parameters	Angular velocity	Acceleration
Dimensions	3 axes (pitch, roll, yaw)	**Dimensions**	3 axes	3 axes
Full scale	±180 deg	**Full scale**	±1200 deg/s	±1600 m/s^2
Angular resolution	0.05 deg	**Linearity**	0.1% FS	0.2% FS
Static accuracy	0.5 deg	**Noise**	0.05deg/s/√Hz	0.003m/s2/√Hz
Dynamic Accuracy	2 deg RMS	**Alignment error**	0.1 deg	0.1 deg
Bandwidth	100 Hz (max.)	**Bandwidth**	100 Hz (max.)	100 Hz (max.)

HMI console

The HMI console, also called graphical user interface for the Intelligent Feedback Prodder Monitoring, is the principal mechanism through which instructor supervises the performance of trainees. The HMI console is divided into several sections that are described below (see Figure 1).

Initialisations
This section encloses two radio buttons mutually exclusive named "New Session" and "Load Session" for initiating a new session or loading an existing one. "New Session" enables resetting all data contained in the interface, while "Load Session" allows replaying a recorded session.

Configuration
This section encloses three radio buttons mutually exclusive that permit loading a predefined configuration file for modifying the objectives of the training session according to the soil type, the soil conditions and the kind of target to be detected.

Session Info
This section contains two different elements that enable to introduce the session ID and the name of the operator that is being monitored with the proposed tool. These texts entries will facilitate the orderly storage of the data and the reporting phase.

Controls
Two different buttons are included for starting or ending the interface activities. Thus, the "Start" button initiates the acquisition, visualisation and recording of data, and finally the "Stop" button halts all the functions of the HMI.

Intelligent Feedback Prodder Status
Two different text messages are included in this section, the first one for informing about the status of the IMU and the second one for describing the status of the force sensor. Thus, these messages notify if sensors are connected or disconnected, if measurement process is being carrying out properly or not, and if some error takes place.

Prodder Monitoring
This VRML graphic reconstructs in real time the orientation of the prodder carried out by the human operator. The graphic enables the instructor to check if each prodding is being performed with a proper angle of insertion.

Force and Orientation Graphics
These two graphics display in real time the force exerted by the human operator while prodding, in N, and the roll, pitch, yaw angles in degrees, describing the orientation of the prodding during the training session.

Force and Angle Data
In this section, data acquired by the intelligent feedback prodder is turn into useful information that will help the instructor to monitor the current situation. Two performance variables are utilised for this purpose: the force exerted by the human operator while prodding in N, and the angle of insertion of the prodder in degrees. Analogic representation of these values, indicating their position relative to normal, abnormal and alarm conditions are displayed. The alarms included for each variable enable the operator to quickly detect values outside the safety range, so he doesn't have to relay in his memory and mentally compare each value to its corresponding defined range to discover deviations of trainee objectives. In addition, colours are utilised in two bar graphics to indicate if the performance is holding or not within the training objectives: green is used for indicating that all the evaluated variables are within the training objectives, yellow for warning that the values are starting to deviate from the goals and red for values out of the defined safety ranges.

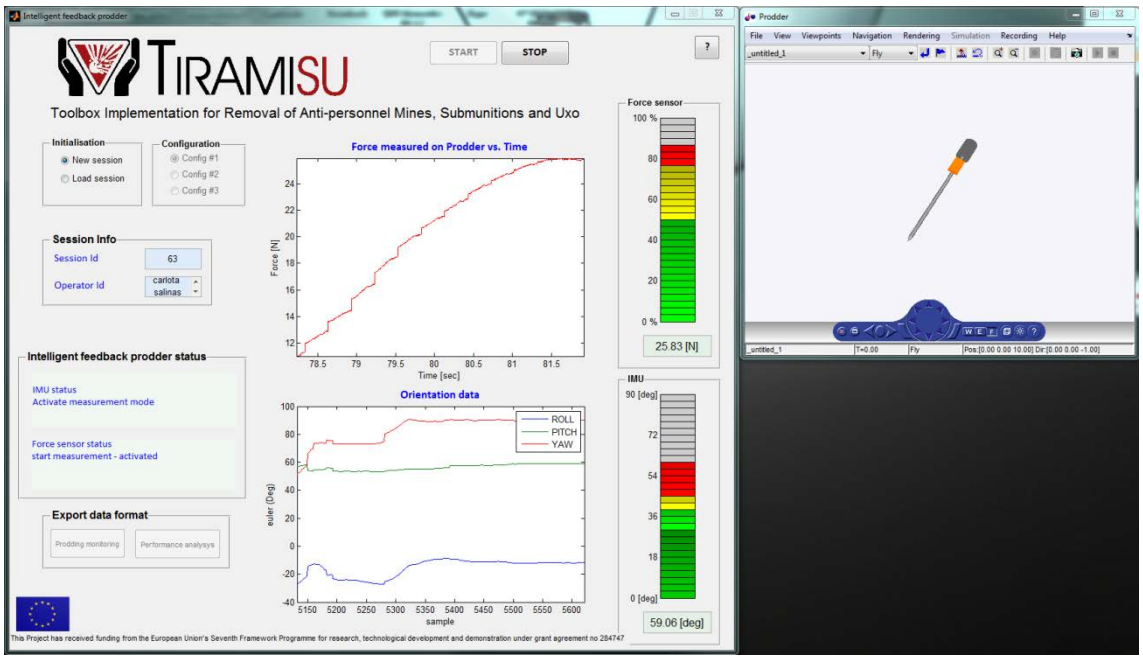

Figure 1. HMI console for the Intelligent Feedback Prodder.

Export Data

This section encloses two buttons called “Prodding Monitoring” and “Performance Analysis”. The first one saves all data acquired by the intelligent feedback prodder during the active session. Lastly, the second button links with an external application that conducts the performance evaluation of the operator and generates the corresponding evaluation report. The performance analysis can be done from the last active session, or from any other session that has been previously stored.

In addition, the interface provides the possibility to modify the limit values of the performance variables (maximum force and maximum angle of insertion) depending on the characteristics of the mission for which the training is being conducted. This feature is achieved through the configuration options. The interface also exhibits ability to record long data-runs without data loss.

Discussion

In this work a HMI has been proposed as part of a training tool for improving the deminers’ skills during close-in detection tasks carried out with prodders. An outline of its main features, functions and components has been described in detail. The proposed HMI has the advantage of providing an overview of the entire operation conducted with the prodder and a limited number of well-defined alarms. In this way, the instructor, or the trained operator can see the entire operation almost at-a-glance. Therefore, it is envisioned that the graphical user interface will improve the instructors’ ability for monitoring, processing and assessing the performance data of the training, reducing the total cognitive load required.

Conclusions

The authors acknowledge funding from the European Commission under 7th Framework Programme (TIRAMISU Grant Agreement Nº 284747) and partial funding from the RoboCity2030-III-CM project (Robótica aplicada a la mejora de la calidad de vida de los ciudadanos. Fase III; S2013/MIT-2748), funded by Programas de Actividades I+D en la Comunidad de Madrid and cofunded by Structural Funds of the EU. Dr. Héctor Montes also acknowledges support from Universidad Tecnológica de Panamá.

References

[1] Habib, M.K. Humanitarian demining mine detection and sensors. In *2011 IEEE International Symposium on Industrial Electronics*, Gdansk, 2011; pp 2237-2242.

[2] Hussein, E.M.; Waller, E.J. Landmine detection: The problem and the challenge. *Applied Radiation and Isotopes* **2000**, *53*, 557-563.

[3] Shimoi, N. *Technology for detecting and clearing landmines*. Morikita Shuppan, Co. Ltd: 2002.

[4] Smith, A. Understanding the use of prodders in mine detection. *The Journal of ERW and Mine Action* **2014**, *18.1*.

[5] Gasser, R. Technology for humanitarian landmine clearance. University of Warwick, 2000.