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Control and Data Acquisition Software of a Mechanism for Moving a Nuclear Fuel Irradiation Capsule: Usability Assessment

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1. Introduction

The most important technical-scientific enterprise being implemented in the current Brazilian nuclear scenario is the "Reator Multipropósito Brasileiro (RMB)", a national multipurpose reactor. The RMB will be an open pool type research reactor, with a maximum power of 30MW [1, 2]. One of the relevant purposes of the RMB is the development of nuclear fuel elements for national reactors. Nuclear fuel must be experimentally qualified and tested in research reactors using experimental facilities known as irradiation circuits, which consist of an irradiation capsule and operational and instrumentation systems [3].

Currently, the Centro de Desenvolvimento da Tecnologia Nuclear (CDTN) is carrying out the technological development of a mechanism for moving an irradiation capsule, called Dispositivo de Movimentação da Cápsula (DMC). This mechanism will be used to carry out experiments known as power ramp tests that will allow the fuel to be characterized considering its thermal efficiency and geometric stability [4]. Functionally, the DMC performs precise and cyclical movements of approach and departure between the irradiation capsule and the reactor core. These movements make it possible to vary the intensity of neutrons flux from the core, which irradiate the fuel. This position variation exposes the fuel to a higher or lower flux of neutrons causing a greater or lesser fuel burnup. Neutronic and thermohydraulic calculations are being performed to ensure that test conditions and safety requirements are met [5]. In addition to the engineering design of the mechanical systems, CDTN also developed the engineering design of the DMC electro-electronic systems. Part of these systems is managed by a data acquisition and control software, developed in the LabVIEW programming language, called "Aplicativo de Controle do Dispositivo de Movimentação da Cápsula do DMC."

In the context of software engineering, usability is a metric related to ease of use of a software by its users [6, 7]. The higher the usability, the simpler it will be to use. This characteristic is of fundamental importance in computer-controlled nuclear systems, where human interaction takes place. Failures and incidents caused by human factors can be closely related to the difficulty in human-computer interaction. One of the causes is related to the failure of developers to make easy the process of learning and using the software. In this scenario, it is pertinent to carry out the usability assessment of a software not only after it is ready, but also during its development process.

2. DMC Control and Data Acquisition Software

A software developed using LabVIEW language has two parts: a front panel (Figure 1), which is usually the user interface, and a block diagram panel (Figure 2).

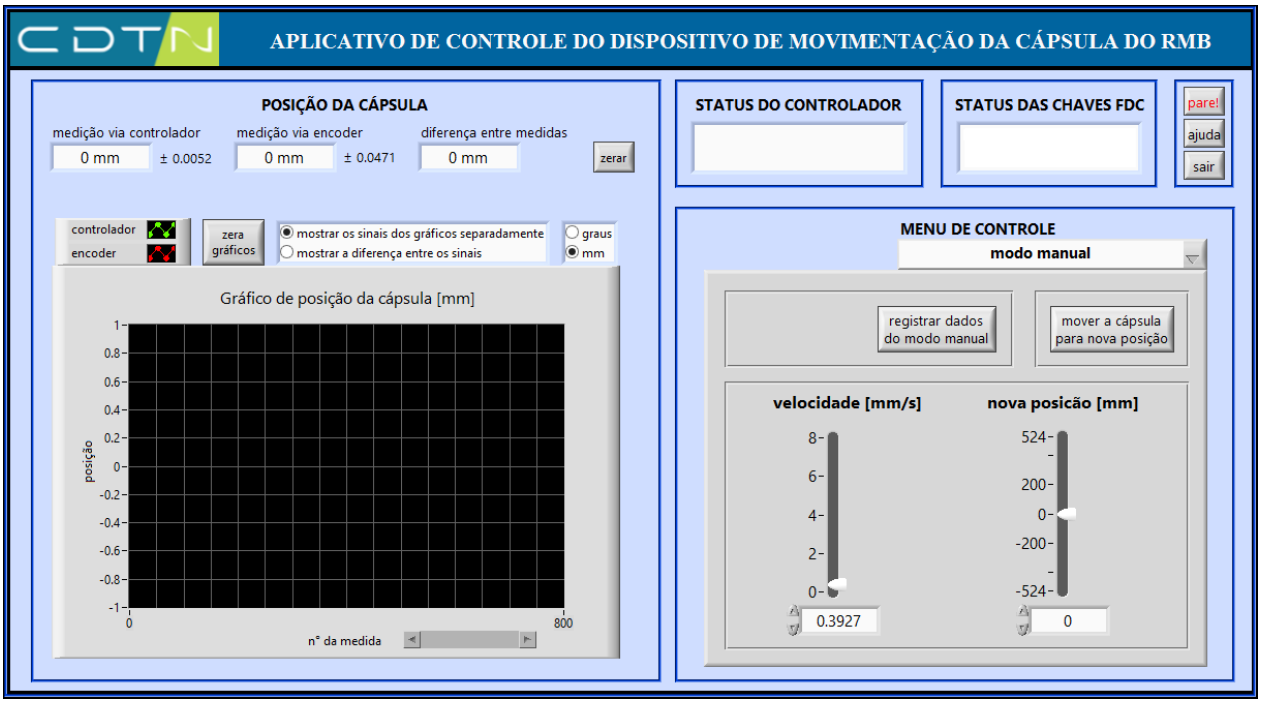


Figure 1: Main graphical interface of the DMC acquisition and control software.

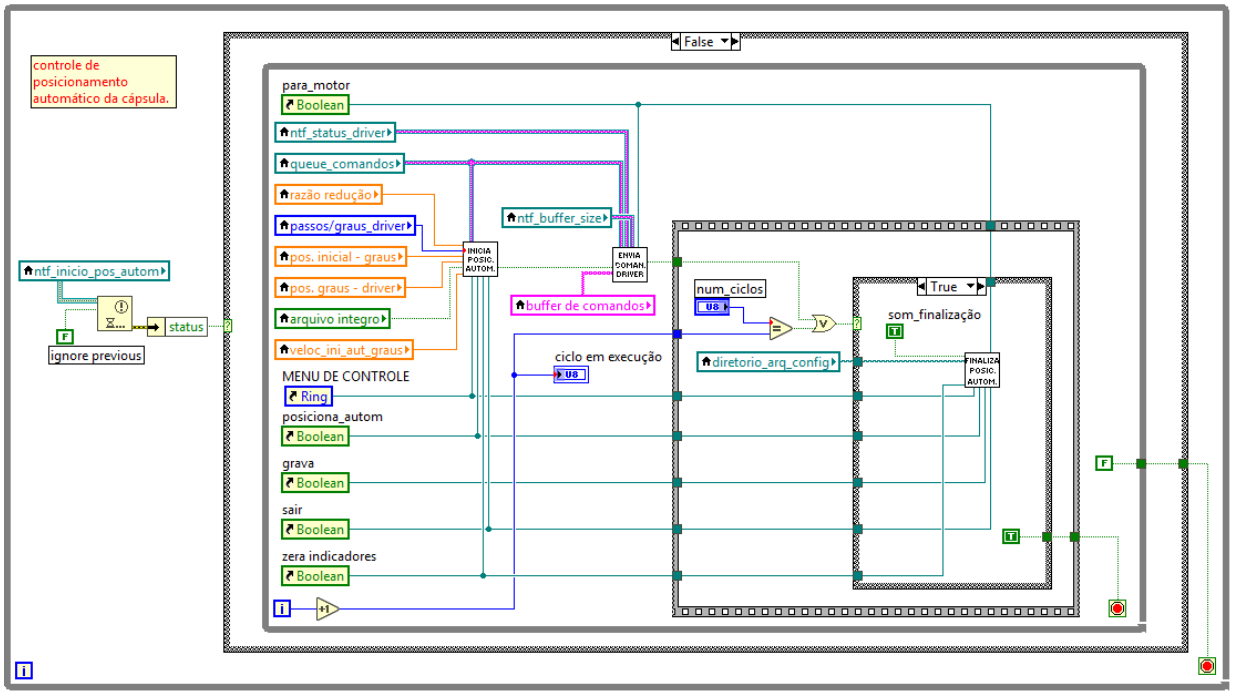


Figure 2: Block diagram containing a small part of software code.

The main functions performed by the DMC control and acquisition software are:

- Remote configuration of the stepper motor controller to run the irradiation capsule movements defined by the power ramp tests.

- Monitoring and data logging: status of operating and safety instrumentation parameters and irradiation capsule position.

- Remote switching of the protection system.

3. DMC Software Usability Assessment

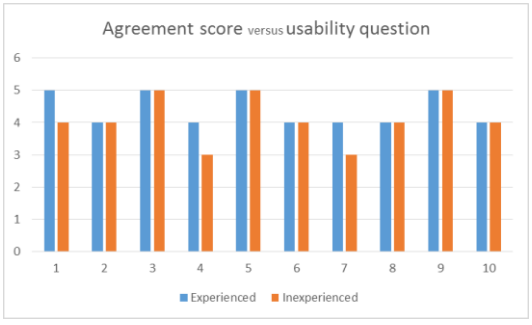
Figure 3 shows the software quality attributes model defined in ISO/IEC 25010 standard [7]. Eight characteristics are categorized: functional suitability, performance efficiency, compatibility, usability, reliability, security, maintainability and portability. Each of the eight characteristics is refined into its own set of sub-characteristics. The focus of this work is on usability, consisting of six sub-characteristics: Appropriateness recognizability, learnability, operability, user errors protection, user interface aesthetics and accessibility. In this work, accessibility was not evaluated.

Figure 3: Characteristics and sub-characteristics of ISO/IEC 25010 software quality attributes model.

To assess the software usability a questionnaire with ten questions was designed covering five of the six sub-characteristics. In this work, accessibility was not evaluated. It was applied to two users with different levels of knowledge and experience in its use. The results were evaluated using ANOVA (Analysis of Variance), single factor without replication.

4. Results and Discussion

Table I: Usability questionnaire results.



ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F critical*
Between Groups	0,45	1	0,45	1,1096	0,3061	4,4139
Within Groups	7,3	18	0,4056			
Total	7,75	19				

Table I shows the ANOVA evaluation of the usability questionnaire results applied to experienced and unexperienced users. The results show that the knowledge and experience skill in using the software did not significantly influence the usability of the software ($F < F_{critical}$). This is an indication of a good software usability related to learnability and operability aspects. Improvements to be implemented should be prioritized on the sub-characteristics identified as most critical by both types of users.

5. Conclusions

Usability metrics from ISO/IEC 25010 standard were used in the quality assessment of a data acquisition and control software used in a mechanism for moving a nuclear fuel irradiation capsule. The evaluation of the software by users with different levels of knowledge and experience in its use allowed the identification of the improvements prioritization to be carried out in some of the features of the graphical interfaces. The results obtained can be used by the current software developers or by their reviewers to improve the usability and the degree of user satisfaction with future versions, helping to meet the reliability and safety requirements of DMC.

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