Automation of the calculation of usability attributes in user tests using RPA and sentiment analysis

Automatización del cálculo de los atributos de la usabilidad en tests con usuarios mediante RPA y análisis de sentimientoss

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RESUMEN

A partir de la gran cantidad de apps desplegadas en las tiendas de aplicaciones en la nube, la usabilidad se ha convertido en un atributo fundamental de la calidad del software para propiciar el diseño centrado en el usuario. Uno de los desafíos en estas pruebas es la automatización del proceso de determinación del nivel de usabilidad, a partir de los atributos de eficacia, eficiencia y satisfacción según la norma ISO 9241-11. En este artículo se propone como aporte el uso de automatización de procesos robóticos (RPA) en la determinación automática de los atributos de eficacia, eficiencia y satisfacción en test con usuarios finales, de cara a la estimación del nivel de usabilidad del software evaluado en la prueba. Para el desarrollo de la presente investigación se hizo uso de una adaptación del patrón iterativo de investigación propuesto por Pratt, de tal modo que se definieron 4 fases: caracterización de las pruebas, definición del proceso, implementación del proceso mediante RPA y evaluación del proceso automatizado. A partir de las métricas asociadas a la eficacia (número de subtareas por tarea), eficiencia (tiempos por tarea) y satisfacción (valoraciones y opiniones del cuestionario pos-test), fue diseñado e implementado un proceso automatizado mediante el uso de la herramienta UiPath, el cual en una hoja de cálculo de Excel determina el porcentaje de eficacia, el porcentaje y el porcentaje de satisfacción, incorporando en el cálculo del último atributo el enfoque de análisis de sentimientos. La prueba de concepto realizada mediante el uso del proceso automatizado fue desarrollada de manera correcta, permitiendo evidenciar su utilidad y aporte tanto en la optimización de los tiempos de análisis de un test con usuarios, como en la incorporación del enfoque de análisis de sentimientos en los análisis convencionales de este tipo de pruebas.

Palabras clave: Análisis de sentimientos, automatización de procesos robóticos, pruebas de usabilidad, test con usuarios, usabilidad.

ABSTRACT

With the large number of apps deployed in cloud application stores, usability has become a fundamental attribute of software quality to enable user-centered de-sign. One of the challenges in usability tests is the automation of the process of determining the level of usability, based on the attributes of effectiveness, efficiency and satisfaction according to ISO 9241-11. This paper proposes as a contribution the use of robotic process automation (RPA) in the automatic determination of the attributes of effectiveness, efficiency and satisfaction in end-user tests, in order to estimate the level of usability of the software evaluated in these tests. For the development of this research, an adaptation of the itera-tive research pattern proposed by Pratt was used, so that 4 phases were de-fined: characterization of the tests, definition of the process, implementation of the process through RPA and evaluation of the automated process. From the metrics associated with effectiveness (number of subtasks per task), efficiency (times per task) and satisfaction (post-test questionnaire ratings and opinions), an automated process was designed and implemented using the UiPath *tool, which in an Excel spreadsheet determines the percentage of effectiveness, the percentage and the percentage of satisfaction, incorporating the sentiment analysis approach in the calculation of the last attribute. The proof of concept performed by using the automated process was correctly developed, allowing to demonstrate its usefulness and contribution both in the optimization of the analysis times of a test with users, as well as in the incorporation of the sentiment analysis approach in the conventional analysis of this type of tests.*

Keywords: Sentiment analysis, robotic process automation, user tests, usability test, usability.

1. INTRODUCTION

With the growth in the number of applications developed and deployed in cloud app stores, usability has become a fundamental attribute of software quality, contributing to improving user productivity in interaction and the competitiveness of companies in the software development field [1], [2]. According to Nielsen, usability can be understood as a quality attribute that allows evaluating how easy to use user interfaces are, and it is defined by 5 quality components: ease of learning, efficiency, memorability, error tolerance, and satisfaction [3], [4].

From the software quality perspective, there are different standards that define usability. According to ISO 9241-11, usability can be defined in terms of effectiveness, efficiency, and satisfaction with which a software product allows a specific set of users to achieve a particular goal in a specific usage context [5]–[9]. In the same vein, according to ISO 9126-1, usability can be understood as the software's ability to be understood, learned, used, and be attractive to the user [4], [10], [11]. On the other hand, according to ISO 9126-4, the concept of usability transforms into the quality of use, defining four attributes: effectiveness, efficiency, satisfaction, and user protection in the interaction with the software. In this way, a new attribute of protection is introduced concerning the ISO 9241-11 concept [11], [12].

Among the concepts presented earlier, the one proposed by ISO 9241-11 is one of the most widely disseminated [13], in which usability is framed in terms of effectiveness, efficiency, and satisfaction. Effectiveness is defined in terms of the accuracy and degree of achievement of user objectives; efficiency refers to the relationship between resources employed and the degree of goal achievement; finally, satisfaction is defined in terms of user comfort in software use [14], [15]. One way to assess the usability of software is through user tests, where a group of users performs a series of tasks in a controlled environment under the supervision of one or more coordinators. These coordinators use the tests to gather inputs for calculating usability attributes and, consequently, the level of usability of the evaluated product [16], [17]. In the case of ISO 9241-11, effectiveness can be determined in a user test using metrics such as the number of tasks; efficiency can be obtained by relating the time spent by the user on each task to the time estimated for each task by the coordinators; finally, satisfaction can be determined through a perception survey [18].

Given the logistics required for user tests, not only within the organization but also in development and analysis, it is advantageous to have different tools that enable the automation of the usability attribute acquisition process. This can be achieved, for example, by leveraging the benefits provided by Robotic Process Automation (RPA). In this way, once the data associated with usability metrics are collected, software robots autonomously determine the usability attributes and the usability level of a test. RPA is a rapidly emerging technology with the goal of enabling process automation through the use of software robots to replicate manual, repetitive, routine, high-volume, and rule-based human tasks [19]–[22]. Given the advantages of RPA in optimizing business processes, it is becoming a crucial component for companies, making them more competitive in dynamic business contexts [23], [24].

In this paper we propose as a contribution the use of robotic process automation (RPA) technologies to automatically obtain the attributes of effectiveness, efficiency and satisfaction within user tests, in order to estimate the level of usability of the software tools that are evaluated in this type of tests. Thus, user tests were characterized, and the process of calculating usability attributes according to ISO 9241-11 was automated. This was achieved by utilizing the UiPath RPA tool and a sentiment analysis approach. As a means of validating the automated process, the results of a conventional usability test were analyzed using a software robot. The robot estimated the usability level based on the calculations of the three test attributes, which were documented in an Excel spreadsheet. For calculating the satisfaction attribute, the software robot employed a Python script capable of extracting three polarities from an opinion. Subsequently, these polarities were used to determine a satisfaction level, which was then integrated with the satisfaction obtained from the post-test questionnaire.

The contributions presented in this article in the realm of RPA and sentiment analysis aim to serve as a reference for extrapolation at both academic and business levels regarding the automation of software testing and the determination of software quality attributes. The remainder of the article is organized as follows: Section 2 introduces the various methodological phases employed in the research development. Section 3 showcases the obtained results, including the characterization of usability tests through the BPMN business modeling language, the implementation of characterized tests using the UiPath tool, and the validation of the automated process through data from a conventional test. Finally, Section 4 presents the conclusions and future work stemming from the current research.

2. METHODOLOGY

For the development of this research, we employed an adaptation of the iterative research pattern proposed by Pratt [25], [26]. Four phases were defined as follows: characterization of the tests, process definition, process implementation through RPA, and finally, evaluation of the automated process (see Figure 1)

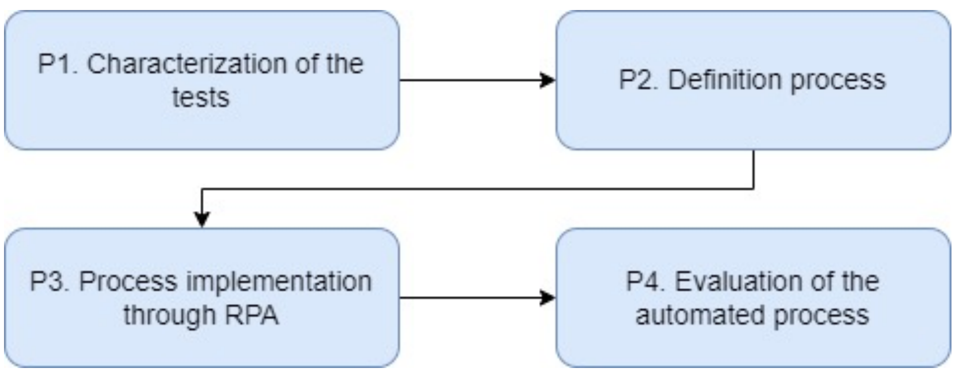

Figure 1. Methodology considered. Fuente: Own.

In Phase 1 of the methodology, the characterization of user tests developed within a controlled environment was conducted. These tests are conventionally structured in 5 stages: confidentiality agreement, pre-test questionnaire, task list, post-test questionnaire, and results analysis (see Figure 2).

In the confidentiality agreement, users are informed that the data obtained in the test will be used solely for academic purposes, ensuring confidentiality with each user. The pre-test questionnaire includes a set of questions aimed at identifying the profile of users who will perform tasks within the test. The task list comprises a set of tasks that the user will independently perform (without coordinator intervention) within the controlled environment or usability lab, while the test coordinator assesses task completion and the time spent on them, aiming to obtain effectiveness and efficiency attributes. The post-test questionnaire consists of a set of qualitative-quantitative questions answered by the user after task completion to identify user perception and, consequently, the satisfaction attribute of usability. In the results analysis stage, pre-test and post-test questionnaires are processed.

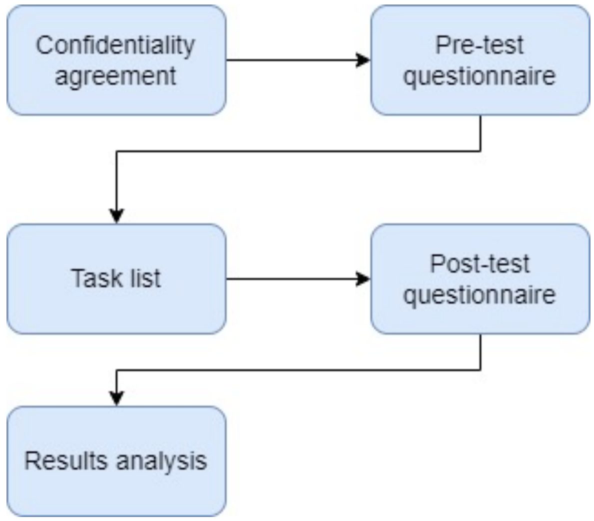

Figure 2. Stages of a user test. Fuente: Own.

Additionally, effectiveness, efficiency, and satisfaction attributes are calculated to determine the usability level of the evaluated software. The overall effectiveness percentage can be obtained by averaging the effectiveness per task, as shown in Equation (1).

$$effectiveness = \frac{effec1 + effec2....effecn}{n} \quad (1)$$

In Equation (1), effec1, effec2, ..., effecn correspond to the calculated effectiveness for a specific task in the user test, where the effectiveness for a task n is defined by Equation (2).

$$effec_n = \frac{subtasks\ of\ task\ n\ completed}{number\ of\ subtasks\ of\ task\ n}\ x\ 100 \quad (2)$$

Likewise, the calculation of the total efficiency percentage is determined based on the average efficiency per task, as depicted in Equation (3).

$$efficiency = \frac{effi1 + effi2 + ... + efficn}{n} \quad (3)$$

In Equation (3), effic1, effic2, ..., efficn correspond to the calculated efficiency for a specific task in the user test, where efficiency for a task n is defined by Equation (4).

$$effic_n = \frac{estimated\ time\ for\ task\ n}{time\ spent\ on\ task\ n} \quad (4)$$

On the other hand, the satisfaction attribute percentage can be calculated by combining the average ratings of the post-test questionnaire questions associated with satisfaction with the perception calculated from the users' opinions in the test, considering the proposal presented in [15]. Thus, the overall satisfaction of the test is represented by Equation (5)

$$satisfaction = \frac{sat\_pos + sat\_sent}{2} \quad (5)$$

In Equation (5), sat_pos corresponds to the satisfaction obtained from the average of the post-test questionnaire questions addressing user perception and is determined through Equation (6).

$$sat\_pos = \frac{Q1 + Q2 + ... + Qn}{n}\ x\ 20 \quad (6)$$

In Equation (6), Q1, Q2,...,Qn correspond to the selected questions from the post-test questionnaire, which range from 0 to 5. The average is multiplied by 20 to scale it within the range of 0 to 100. Similarly, the calculation of the variable sat_sent is done using Equation (7).

$$sat\_sent = \left(\frac{x}{\sqrt{x^2+a}} + \frac{\sqrt{1+a}-1}{\sqrt{1+a}}\right) x\, 100 \quad (7)$$

In Equation (7), x represents the difference between positive polarity and negative polarity, while a is a complementary value that ensures exact roots, allowing it to take on values such as 3, 8, 15, etc. Thus, once the equations for the three attributes are presented, it is possible, through Equation (8), to calculate usability.

$$usability = \frac{effectiveness + efficiency + satisfaction}{3} \quad (8)$$

Hence, it is evident that once the inputs for determining usability attributes are captured in the test, their calculation requires significant effort on the part of the test coordinators. Therefore, automating this process becomes necessary. In Phase 2, building upon the characterization of user tests developed in Phase 1, the previous process was adapted with the intervention of a software robot (RPA). In Phase 3 of the methodology, the adapted process from Phase 2 was implemented using the UiPath RPA tool. Finally, in Phase 4 of the methodology, the relevance of the automated process was evaluated through a proof of concept, utilizing data from a conventional usability test. Additionally, in this phase, a time comparison was conducted to assess the optimization of the process by incorporating the software robot in the usability calculation of a software product.

3. RESULTS Y DISCUSSION

As mentioned in the methodology of this work, initially, and using the BPMN modeling language, the conventional process carried out in a user test was characterized (see Figure 3). To achieve this, the online tool bpmn.io was employed.

As depicted in Figure 3, user tests involve two key roles: the user and the test coordinator, where the coordinator role includes the supervisor and test analyst. Once the test supervisor agrees on a schedule with the user, the supervisor proceeds to email the connection link and the documents to be completed during the test by the users. Upon reading the test instructions and connecting to the link with the supervisors, the user receives an explanation about the test logistics. The user can then decide whether or not to proceed; if choosing to continue, the user signs the confidentiality agreement, fills out the pre-test questionnaire and follows through with the execution of each interaction task defined by the coordinators in a specific software. After completing the tasks, the user proceeds to fill out the post-test questionnaire for the test.

As the user progresses through the tasks, the test supervisor assesses the completion of subtasks within each task and measures the time spent on each task, recording this data in an Excel document. Similarly, after the user has completed the post-test questionnaire, the ratings from a selected set of questions (associated with perception) and the responses to open-ended questions are recorded in the Excel document for processing through sentiment analysis. Once the test data is documented in the Excel file, the test analyst calculates task-specific effectiveness and overall test effectiveness using equations (1) and (2) through the spreadsheet. Subsequently, the test analyst continues with the process, obtaining task-specific efficiency and overall test efficiency using equations (3) and (4) through the spreadsheet. Finally, the analyst proceeds with the calculation of satisfaction in the spreadsheet using equations (6), (7), and (8). It is worth mentioning that for satisfaction calculation based on sentiment analysis, the analyst needs to externally obtain the polarities of user opinions using external applications or programming libraries such as VaderSentiment and Paralleldots.

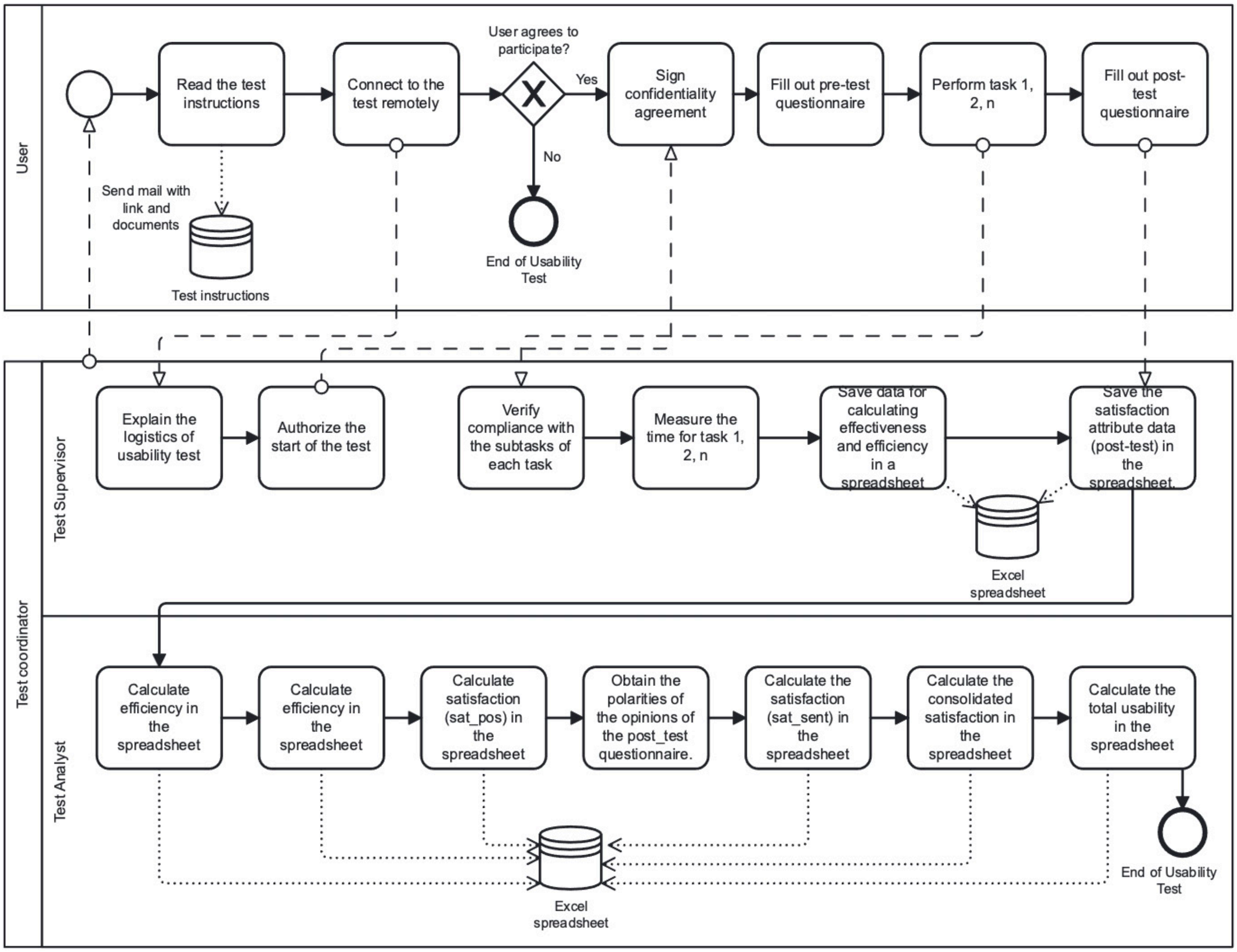

Figure 3. Characterization of a conventional user test. Fuente: Own.

Once the process of usability tests has been characterized, the automated process using software robots is presented, optimizing tasks for the software analyst, as illustrated in Figure 4. The software robot is programmed to access the Excel spreadsheet of the test, retrieve the data, and apply Excel formulas associated with the equations for effectiveness, efficiency, and satisfaction. In the case of satisfaction, the software robot is specifically designed to run a Python script in the background. This script takes each user opinion from the test as input and produces both the polarities of the opinions using the VaderSentiment library and the perception level associated with each opinion using Equation (7). Unlike the conventional process where the test analyst manually checked polarities using services like ParallelDots, in this process, the software robot automatically determines the consolidated satisfaction (combination of sat_pos and sat_sent). Once the usability attributes are obtained, the software robot calculates usability per user and the overall usability of the test, recording these values in the spreadsheet. Finally, the software robot automatically generates a graph representing usability per user throughout the test. This is made possible through the document manipulation and management functions supported by the UiPath tool.

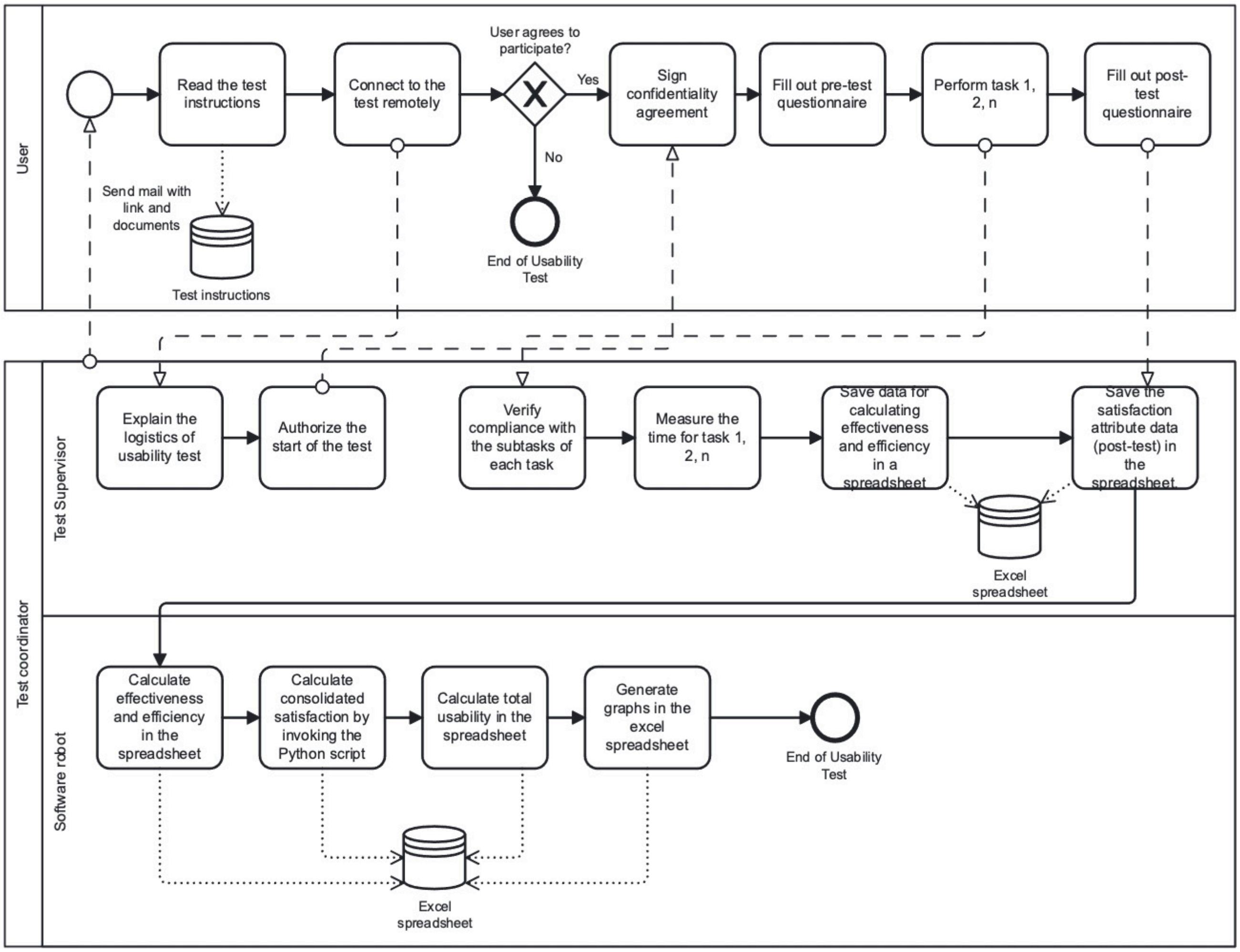

Figure 4. Automated process with RPA. Fuente: Own.

Once the automated process for analyzing user tests was described, these processes were implemented in the UiPath tool. Figure 5 illustrates the execution of the process in this tool, using sample data associated with a user test.

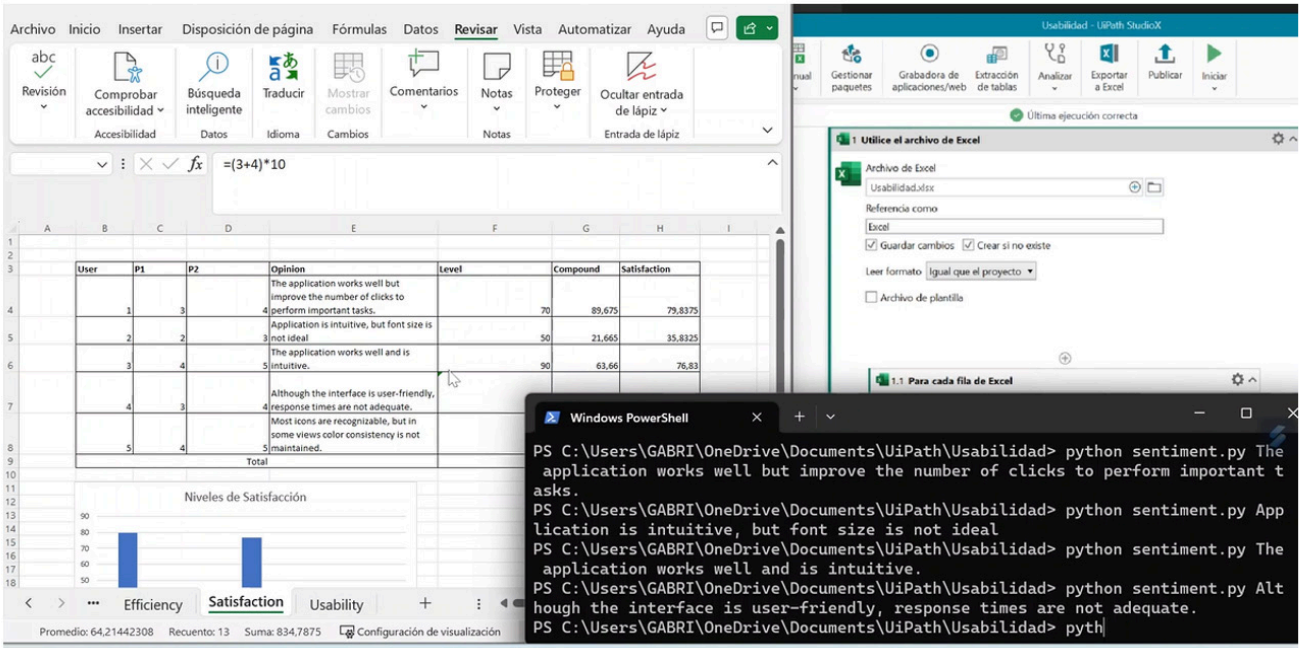

Figure 5. Process implementation with UiPath. Fuente: Own.

In Figure 5, it is specifically shown how the UiPath-programmed software robot is performing calculations in the 'Satisfaction' tab. In this tab, it calculates the perception based on the ratings from the post-test questionnaire (sat_pos) and combines it with the perception obtained through the application of sentiment analysis techniques (sat_sent). This is done in the background using a Python script, which calculates polarities through the use of the VaderSentiment library (see Figure 6). The perception from the polarities is calculated using the compound function of the VaderSentiment library, which implements Equation 7.

sentiment.py

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```
from vaderSentiment.vaderSentiment import
SentimentIntensityAnalyzer

l=sys.argv
op=' '.join(l[1:])
an=SentimentIntensityAnalyzer()
resp=an.polarity_scores(op)
arch=open("reporte.csv","w")
pos=str(resp['pos'])
neu=str(resp['neu'])
neg=str(resp['neg'])

p=resp['pos']
n=resp['neu']
ne=resp['neg']
comp=resp['compound']
perc=((comp+1)/2)*100
arch.write(pos+";"+neu+";"+neg+";"+str(perc)+"\n")
arch.close()
```

Figura 6. Sentiment analysis script. Fuente: Own.

Table 1. Time comparison between conventional and RPA user tests

Subtask of the user test analysis process	Estimated time for the test coordinator	Time spent by the software robot
Efficiency calculation and graph generation	90 seconds	15 seconds
Efficiency calculation and graph generation	90 seconds	15 seconds
Satisfaction calculation and graph generation	150 seconds	45 seconds
Usability calculation and graph generation	90 seconds	5 seconds
Total	420 seconds	80 seconds

In order to assess the efficiency of the automated process, Table 1 provides a time comparison for various subtasks associated with the user test analysis process. This comparison takes into account the estimated time for a test coordinator versus the measured time for the UiPath-implemented software robot. In the case of satisfaction calculation, it is assumed that the evaluator utilizes external services, such as those provided by ParallelDots.

The results obtained from Table 1 lead to the conclusion that the software robot performs the analysis of post-test questionnaires five times faster than a test coordinator. After comparing conventional tests with those conducted by a software robot, the calculations obtained by the UiPath-implemented software robot for a specific case study or proof of concept are presented. In this particular case study, consisting of 2 tasks with 5 users, the effectiveness attribute was considered. The study accounted for 3 subtasks in the first task and 4 subtasks in the second task. Table 2 displays the results obtained by the software robot within 15 seconds for efficiency calculation.

Table 2. Results obtained for the effectiveness attribute

User	Subtasks T1	Subtasks T2	Effect1	Effect2	Total
1	2	4	66.67	100.00	83.34
2	2	3	66.67	75.00	70.84
3	3	4	100.00	100.00	100.00
4	2	3	66.67	75.00	70.84
5	2	3	66.67	75.00	70.84
Total			73.33	85.00	79.17

The results from Table 2 demonstrate that user 3 effectively completed all tasks, while users 2, 4, and 5 did not effectively fulfill either of the two tasks. The overall average efficiency for task 1 was 73.33%, for task 2 was 85%, and finally, for the entire test, it was 79.17%. Regarding the efficiency attribute, Table 3 presents the results calculated by the software robot in 15 seconds. For task 1, it was estimated that users would take 2 minutes, while for task 3, a duration of 3 minutes was estimated.

Table 3. Results obtained for the efficiency attribute

User	Time T1	Time T2	Effic1	Effic2	Total
1	3	2	66,67	66,67	66,67
2	2	3	100,00	100,00	100,00
3	2	4	100,00	133,33	116,67
4	1	2	200,00	66,67	133,34
5	3	4	66,67	133,33	100,00
Total			106,67	100,00	103,33

According to Table 3, it is evident that user 1 was the only one who completed the tasks in a time less than estimated by the coordinators, while the rest of the users tackled the tasks in a time less than estimated. Likewise, it is observed that the average efficiency for task 1 was 106.67%, for task 2 was 100%, and for the overall test, it was 103.33%. On the other hand, Table 4 presents the results for the satisfaction attribute in the proof of concept, where two questions from the post-test questionnaire and one opinion per user were considered. The opinions were evaluated in English, as the VaderSentiment tool operates with opinions in that language.

Table 4. Results obtained for the satisfaction attribute

User	P1	P2	Opinion	Level	Compound	Satisfaction
1	3	4	The application works well but improve the number of clicks to perform important tasks.	70	89,675	79,8375
2	2	3	Application is intuitive, but font size is not ideal	50	21,665	35,8325
3	4	5	The application works well and is intuitive.	90	63,66	76,83
4	3	4	Although the interface is user-friendly, response times are not adequate.	70	41,525	55,7625
5	4	5	Most icons are recognizable, but in some views color consistency is not maintained.	90	50	70
Total				74	53,305	63,6525

Upon analyzing the combined satisfaction, it can be concluded that, in the case of users 1, 3, and 5, this value is above 70%, while for users 2 and 4, it is below 56%. Likewise, it can be observed that the consolidated average for the satisfaction attribute is 63.65%. Finally, when calculating the total usability per user using Equation (8), it is possible to obtain the bar chart presented in Figure 7.

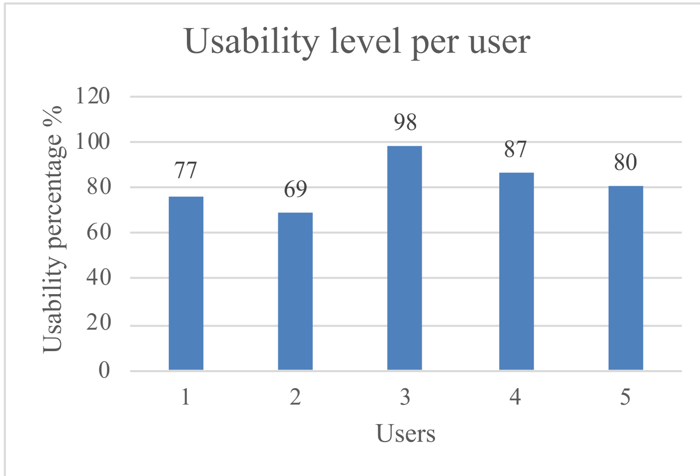

Figura 7. Niveles de usabilidad por usuario. Fuente: Propia.

Based on Figure 7, it is possible to observe that the highest usability level is achieved by user 3 with 97.83%, while the lowest usability level is obtained for user 2 with a percentage value of 69.89%. Finally, the overall usability level for the evaluated software in the proof of concept is 82.05%.

This article proposed a new approach to automate the user test analysis process, aiming to estimate the usability level based on the calculation of effectiveness, efficiency, and satisfaction attributes, leveraging the advantages provided by Robotic Process Automation (RPA). In this context, a software robot was implemented using the UiPath tool. This robot, utilizing user test data recorded in an Excel spreadsheet, determines the usability level per user and for the entire test, through the prior calculation of the three attributes defining usability according to ISO 9241-11. As an added value to the presented proposal, the use of sentiment analysis technique is highlighted as a complement to the satisfaction attribute calculation, as suggested in [15], which introduces a tool to support satisfaction attribute calculation. Thus, in comparison to the approach in [15], the test analysis automation not only encompasses satisfaction attribute calculation but also includes effectiveness and efficiency attribute calculations, along with the determination of the satisfaction attribute. Similarly, the software robot is integrated into the Excel office tool, which evaluators traditionally find more accustomed to handling test data.

Similarly, the proposal presented in this article contributes to what is suggested in [27], where a tool based on fuzzy logic is introduced for determining the level of usability by calculating the three attributes that define usability according to ISO 9241-11. This is noteworthy, considering that the present proposal incorporates a sentiment analysis approach into the satisfaction attribute calculation. Moreover, the calculations of the usability level and its attributes in this proposal are automated through a software robot and included in a spreadsheet where the test results are recorded. This proposal offers an easily accessible alternative, given the widespread use of spreadsheets in usability test data analysis.

4. CONCLUSIONS AND FUTURE WORK

Taking advantage of the benefits provided by RPA in automating repetitive and rule-based processes, this work proposed a contribution in the form of automating the process of estimating the usability level in a user test, based on the determination or calculation of effectiveness, efficiency, and satisfaction attributes. This proposal aims to be useful for optimizing the analysis work carried out by usability test coordinators once the data associated with these metrics have been collected. Additionally, this approach intends to serve as a reference for extrapolation in software engineering contexts, for determining other quality attributes, considering their respective metrics.

In addition to incorporating RPA into the process of determining the usability level and its associated attributes according to ISO 9241-11, this approach introduces a novel contribution by integrating sentiment analysis into the estimation of the satisfaction attribute of usability. In this regard, a Python script running in the background was utilized, leveraging the VaderSentiment library to obtain polarities associated with an opinion and consequently determine the perception derived from sentiment analysis (sat_sent). Thus, this proposal also aims to enhance the traditional method employed for determining the satisfaction attribute of usability.

The UiPath tool proved to be suitable for implementing a software robot that estimates the calculation of usability level in a user test based on the attributes of effectiveness, efficiency, and satisfaction. The main advantage of the UiPath tool lies primarily in its capabilities for manipulating spreadsheets (accessing cell information, including formulas, updating charts, among others) and for invoking external applications from the operating system console. This latter advantage enabled the integration of sentiment analysis functionalities into a conventional Excel spreadsheet.

Through the implementation of the automated process for determining usability levels in user tests using UiPath, it was possible to estimate that the time taken by the software robot in this analysis is five times less than that of a usability test coordinator. This is attributed to the necessity of incorporating formulas, generating charts, and including data from external sources (for example, using the sentiment analysis online service provided by ParallelDots). Additionally, the automated process was successfully evaluated in a test involving 5 users and 2 tasks, resulting in an average usability level of 82.05%. The obtained results lead to the conclusion that the use of RPA is relevant in optimizing usability tests. Furthermore, given the similarities, this approach could be applied to automate black-box software testing.

As a future work stemming from this research, we aim to: a) integrate fuzzy logic models for determining the usability level based on input values from the effectiveness, efficiency, and satisfaction attributes; b) extrapolate the proposed approach to determine other software quality attributes, including usability attributes outlined in ISO 9126-1.

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REFERENCES

[1] D. Hering, T. Schwartz, A. Boden, and V. Wulf, "Integrating Usability-Engineering into the Software Developing Processes of SME: A Case Study of Software Developing SME in Germany," in 2015 IEEE/ACM 8th International Workshop on Cooperative and Human Aspects of Software Engineering, May 2015, pp. 121–122. doi: 10.1109/CHASE.2015.22.

[2] K. Puri and S. K. Dubey, "Analytical and critical approach for usability measurement method," in 2016 3rd International Conference on Computing for Sustainable Global Development (INDIACom), 2016, pp. 4045–4050.

[3] J. Nielsen, "Usability 101: Introduction to Usability," 2012. [Online]. Available: https://www.nngroup.com/articles/usability-101-introduction-to-usability/

[4] L. Cheikhi, A. Abran, and W. Suryn, "Harmonization of usability measurements in ISO9126 software engineering standards," in 2006 IEEE International Symposium on Industrial Electronics, Jul. 2006, pp. 3246–3251. doi: 10.1109/ISIE.2006.296137.

[5] W. Sanchez, “La usabilidad en ingeniería de software: definición y características,” Ing-novación, no. 2, pp. 7–21, 2011, Accessed: Oct. 20, 2020. [Online]. Available: https://core.ac.uk/download/pdf/47264961.pdf

[6] I. Feroz, N. Ahmad, and M. W. Iqbal, “Usability Based Rating Scale for Mobile Health Applications,” in 2019 International Conference on Engineering and Emerging Technologies (ICEET), Feb. 2019, pp. 1–7. doi: 10.1109/CEET1.2019.8711845.

[7] D. Fathiyyah, M. D. Sulthon Diani, Z. Ayuning Saputri, and Sunardi, “Usability Evaluation on Life Insurance Application Using System Usability Scale and ISO 9241-11,” in 2022 8th International HCI and UX Conference in Indonesia (CHIuXiD), Nov. 2022, pp. 94–99. doi: 10.1109/CHIuXiD57244.2022.10009774.

[8] F. H. Nakagawa, A. S. Felinto, and M. T. Omori, “Inclusion of Teaching Slides in Games: Analysis of the Efficiency, Effectiveness and Satisfaction,” IEEE Lat. Am. Trans., vol. 11, no. 6, pp. 1372–1377, Dec. 2013, doi: 10.1109/TLA.2013.6710386.

[9] D. A. Albornoz, S. A. Moncayo, S. Ruano-Hoyos, G. E. Chanchí-Golondrino, and K. Márceles-Villalba, “Sistema software para la ejecución de pruebas de usabilidad bajo el enfoque de mouse tracking,” TecnoLógicas, vol. 22, pp. 19–31, Dec. 2019, doi: 10.22430/22565337.1511.

[10] C. Santos, T. Novais, M. Ferreira, C. Albuquerque, I. H. de Farias, and A. P. C. Furtado, “Metrics focused on usability ISO 9126 based,” in 2016 11th Iberian Conference on Information Systems and Technologies (CISTI), Jun. 2016, pp. 1–3. doi: 10.1109/CISTI.2016.7521437.

[11] J. L. Gozález-Sánchez, F. Montero-Simarro, and F. L. Gutiérrez-Vela, “Evolución del concepto de usabilidad como indicador de calidad del software. José-Luis González-Sánchez, Francisco Montero-Simarro, Francisco-Luis Gutiérrez-Vela,” Rev. Int. Inf. Doc. Bibl. y Comun., vol. 21, no. 5, pp. 529–536, 2012, Accessed: Oct. 17, 2020. [Online]. Available: http://www.elprofesionaldelainformacion.com/contenidos/2012/septiembre/13.html

[12] A. Leon-Montano and L. Barba-Guaman, “Design of the architecture for text recognition and reading in an online assessment applied to visually impaired students,” in 2020 International Conference of Digital Transformation and Innovation Technology (Incodtrin), Oct. 2020, pp. 59–65. doi: 10.1109/Incodtrin51881.2020.00023.

[13] P. Weichbroth, “Usability of Mobile Applications: A Systematic Literature Study,” IEEE Access, vol. 8, pp. 55563–55577, 2020, doi: 10.1109/ACCESS.2020.2981892.

[14] AENOR, “UNE-EN ISO 9241-11,” 1998.

[15] G. E. Chanchí-Golondrino, L. F. Muñoz-Sanabria, and L. M. Sierra-Martínez, “Estimación del atributo de satisfacción en test con usuarios mediante técnicas de análisis de sentimientos,” Prospectiva, vol. 21, no. 2, pp. 40–50, 2023, doi: https://doi.org/10.15665/rp.v21i2.3248.

[16] G. E. Chanchí, D. M. Delgado, D. F. Girón Timaná, and K. Márceles Villalba, “Estimación del atributo satisfacción en test de usuarios a partir del análisis de la expresión facial,” Rev. Ing. Univ. Medellín, vol. 19, no. 36, pp. 13–28, Jun. 2019, doi: 10.22395/rium.v19n36a1.

[17] C. J. Mueller, D. Tamir, O. V. Komogortsev, and L. Feldman, “An Economical Approach to Usability Testing,” in 2009 33rd Annual IEEE International Computer Software and Applications Conference, 2009, pp. 124–129. doi: 10.1109/COMPSAC.2009.26.

[18] G. Enriquez and S. Casas, “Usabilidad en aplicaciones móviles,” Inf. Científico Técnico UNPA, vol. 5, no. 2, pp. 25–47, 2013, Accessed: Oct. 20, 2020. [Online]. Available: https://dialnet.unirioja.es/servlet/articulo?codigo=5123524&info=resumen&idioma=SPA

[19] N. Zhang and B. Liu, “Alignment of business in robotic process automation,” Int. J. Crowd Sci., vol. 3, no. 1, pp. 26–35, May 2019, doi: 10.1108/IJCS-09-2018-0018.

[20] J. G. Enriquez, A. Jimenez-Ramirez, F. J. Dominguez-Mayo, and J. A. Garcia-Garcia, “Robotic Process Automation: A Scientific and Industrial Systematic Mapping Study,” IEEE Access, vol. 8, pp. 39113–39129, 2020, doi: 10.1109/ACCESS.2020.2974934.

[21] D. Choi, H. R’bigui, and C. Cho, “Enabling the Gab Between RPA and Process Mining: User Interface Interactions Recorder,” IEEE Access, vol. 10, pp. 39604–39612, 2022, doi: 10.1109/ACCESS.2022.3165797.

[22] B. Vajgel et al., “Development of Intelligent Robotic Process Automation: A Utility Case Study in Brazil,” IEEE Access, vol. 9, pp. 71222–71235, 2021, doi: 10.1109/ACCESS.2021.3075693.

[23] I. E. Nielsen, A. Piyatilake, A. Thibbotuwawa, M. M. De Silva, G. Bocewicz, and Z. A. Banaszak, “Benefits Realization of Robotic Process Automation (RPA) Initiatives in Supply Chains,” IEEE Access, vol. 11, pp. 37623–37636, 2023, doi: 10.1109/ACCESS.2023.3266293.

[24] E. Hartikainen, V. Hotti, and M. Tukiainen, “Improving Software Robot Maintenance in Large-Scale Environments–is Center of Excellence a Solution?,” IEEE Access, vol. 10, pp. 96760–96773, 2022, doi: 10.1109/ACCESS.2022.3205420.

[25] G.-E. Chanchí-Golondrino, M.-A. Ospina-Alarcón, and F. Rico-Rodríguez, “Propuesta de un conjunto de recomendaciones de accesibilidad para mejorar el posicionamiento de portales web empresariales,” Rev. Científica, vol. 45, no. 3, pp. 390–401, Sep. 2022, doi: 10.14483/23448350.19374.

[26] K. Pratt, “Design Patterns for Research Methods: Iterative Field Research,” 2009. [Online]. Available: http://kpratt.net/wp-content/uploads/2009/01/research_methods.pdf

[27] G. E. Chanchí-Golondrino, L. M. Sierra-Martínez, and W. Y. Campo-Muñoz, “Fuzzy Logic-Based System for the Estimation of the Usability Level in User Tests,” Int. J. Comput. Commun. Control, vol. 17, no. 2, 2022.