Usage Models for Smart Grading, Handling and Packaging Solutions in Agile and Reconfigurable Lines

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Abstract

from one location to another. Today, robots are essential in this field. The European sector's share reaches 23 %, yet Europe must still compete with China, Japan, and Korea. Improved efficiency and innovative solutions would be an advantage. However, the transportation of deformable objects such as plastic items and food still cannot be handled by robots. The EU-funded AGILEHAND project will develop innovative technologies that will allow robots to smartly handle and package soft and deformable objects in agile and reconfigurable lines, while intelligence solutions will monitor, control, and synchronize production and logistics for improved efficiency. AGILEHAND's solutions will be demonstrated in four industrial pilots. The work presented here is focused on the testing procedures used for validating and assessing the basics of AGILEHAND solutions functionality and increasing the user-friendliness.

Keywords

UI/UX, Usability testing, Agile processing lines, Product grading, Product Handling, Product Packing

1. Introduction

The conveyor system market and, in particular, robot segment for the automated material handling are experiencing double-digit growth at a compound annual growth rate (CAGR). EU manufacturers in this sector play a significant role, covering 23% of the market but this technological edge is being challenged due to the astonishing growth of China, Japan, and Korea [1]. In the real world, many objects to be handled, including food, clothes, bottles, or plastic items, are soft or deformable and robots are not yet efficient and effective in handling these objects.

In this context, EU funded project AGILEHAND [2], aims at developing advanced technologies for grading, handling, and packaging autonomously soft and deformable products, as a strategic instrument to improve flexibility, agility and reconfigurability of production and logistic systems of the European manufacturing companies.

AGILEHAND project will deploy 3 integrated Suites: 1) Smart Sensing Suite, self-calibrating sensing solutions to grade the quality (both interior and exterior) of delicate objects and to produce a mesh of integrated and overlapping sensors that will improve production-line traceability, agility and reconfigurability; 2) Self-Adaptive Handling, Sorting And Packaging Suite, robotic manipulation systems that reacts to product quality and that can Pick-Up and Re-Orientated Different Soft and

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Deformable Products without causing product damage considering collaborative (human-in-the-middle) approaches; 3) Agile, Flexible And Rapid Reconfigurable Suite, a set of AI based solutions that will allow for monitoring, adaptive control and synchronization of production and logistics flows in a factory, even when faced with a variability of products, production mix or fresh market, guaranteeing high performance in customer response time, and an efficient use of resources.

The AGILEHAND Solutions will be demonstrated in 4 industrial pilots that differ in characteristics of the surface, deformability, and consistency of the products to be handled.

The work presented here is focused on the testing procedures used for validating and assessing the basics of AGILEHAND solutions functionality and increase user-friendliness. Regarding the software mock-ups, these are developed through service virtualization, API mocks and simulators. These tools will allow the creation of user interfaces that show the end-user what the software will look like without having to build the software or the underlying functionality. These software UI (User Interface) mockups are semi functional user interfaces developed in a software development tool. Usage models and mock-ups are used by AGILEHAND solutions designers mainly to acquire feedback from users.

2. Design Tool and Methodology

This section focusses on describing the tool and methodology used for designing the UI component of AGILHAND platform, described previously. Designing good user interfaces is often a challenging process which comprises consideration of several factors such as good functional and systematic requirement analysis. To cover all aspects of the design process a fully functional tool is a necessity which can support all kinds of design process needs. One such tool that supports a wide variety of such functionalities and is openly accepted in enterprise practices is a cloud-based design tool called Figma [3]. This tool allows designing mock-ups for user interfaces with the ability to add interaction to them by prototyping feature. A brief visual look of Figma in workflow is presented in **Figure 1**.

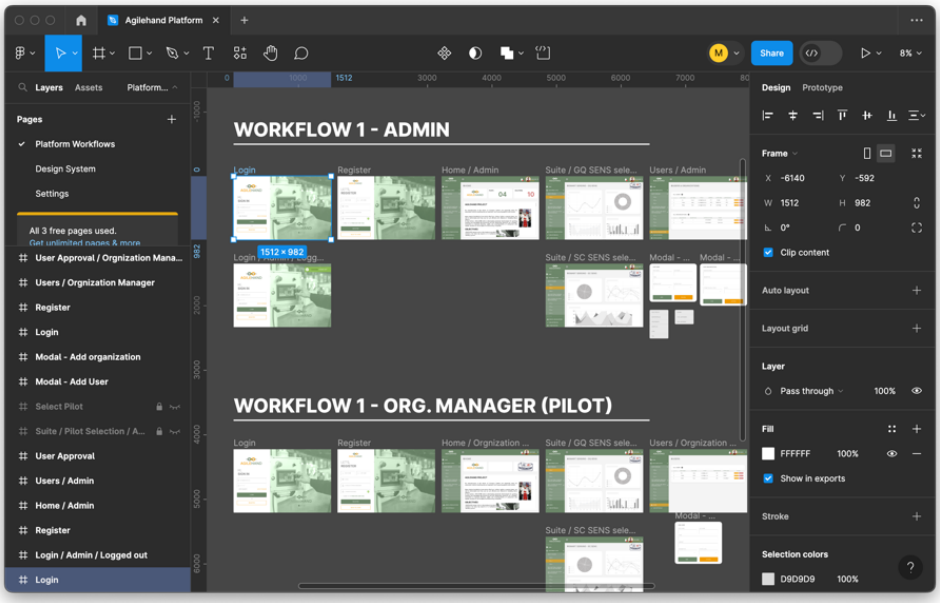

Figure 1: Figma tool interface

Figma offers prototyping functionality to simulate application workflows. Prototypes provide screen to screen navigation, individually interactable animated components and responsive design to ensure consistency of user experience across multiple devices and screen sizes.

A good user interface must incorporate user feedback to have accessible, user friendly and highly interactive design. A high-quality user experience largely depends on user-friendliness of UI.

One way to achieve user-friendliness is through a co-creation approach, which involves continuous collaboration and participation of end-users to gather feedback and insights which can be used to refine the product design. Agilehand common platform mock-up is designed using this

approach of active participation from involved end-users to ensure a final system that is built on user expectations.

3. Usability Testing

Usability testing is a systematic evaluation of ease of use and user friendliness in a product or system which is usually performed through direct participation from stakeholders and end-users by providing relevant observation and feedback on the experience [4]. The goal of usability is to pinpoint design issues and make improvements to ultimately enhance overall user experience (UX). User-centered design in software development has grown in recent years which is why usability testing has become essential in the design process. The proposed model for Agilehand platform usability testing can be seen in Figure 2.

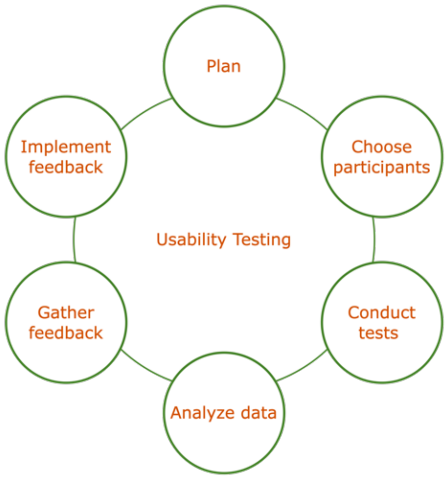

Figure 2: Usability testing model

The usability testing uses the System Usability Scale (SUS) [5], which is a widely adopted user interface usability testing standard and provides a rigorous framework to assess UI/UX through quantitative metrics. Following SUS derived measures were adopted to evaluate usability of Agilehand platform UI:

Task Success Rate: This metric calculates the proportion of participants who completed a given set of tasks. Higher rate of this metric indicates ease of use.

Time of Task: Measures the time taken by participants to complete each task. It can help identify potential issues that may arise during interaction with the system design.

Error Rate: Errors occurred during any task such as deviation due to miss clicks or incomplete task.

Test Completion Time: Overall completion time combined from individual task completion time. This metric offers a comprehensive look of how long it took users to complete the whole usability test.

Click Heatmaps and User Flow Patterns: User click tracking and navigation patterns allow identification of common behaviors, user expectations and facilitate optimization of UX.

Questionnaires and Surveys: Qualitative feedback through this metric gives valuable information regarding perception of the UI, overall satisfaction, preferences, and suggestions for improvement.

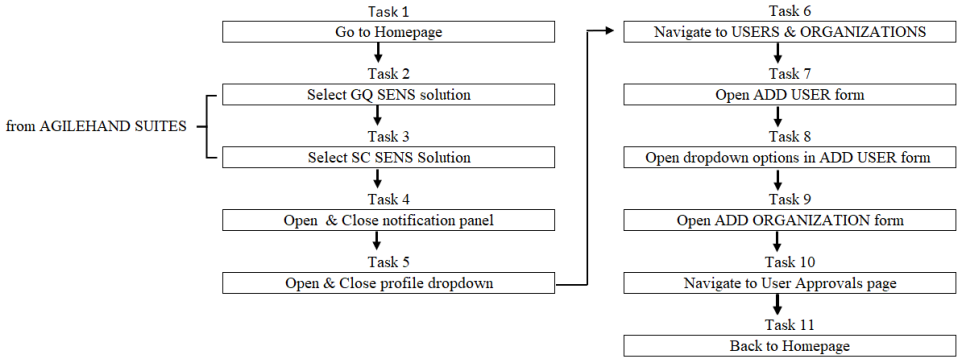

Figure 3: Workflow of test scenarios

In the context of useability assessment of Agilehand common platform prototype, a series of test scenarios are included in the evaluation through systematic and structured approach. These scenarios include brief instruction within each task. Participants are asked to perform 11 actions on the prototype followed by a set of 6 open-ended questions designed to bring forth qualitative feedback from users regarding over satisfaction with the presented platform user interface.

The workflow of the test scenarios is shown in Figure 3.

Following set of questions are asked to participants after performing prototype tasks:

Question 1: On a scale of 1 to 5, how easy was it to navigate through the dashboard?

Question 2: How long did it take you to complete all the tasks using the dashboard?

Question 3: On a scale of 1 to 5, how many clicks were required to access different sections of the dashboard?

Question 4: How satisfied are you with the overall design and layout of the dashboard?

Question 5: Were there any specific elements or features that you found confusing?

Question 6: Can you provide any suggestions for improving the overall user experience of the dashboard?

At the end of this questionnaire the test scenario ends with an optional access to design file to open in Figma where any future feedback can be left directly on the design. Which may be addressed by the designers shortly.

The test scenario described above has been created and shared through an online testing platform called Useberry [6]. This online platform allows conducting usability tests for digital prototypes for web and mobile apps. Useberry can be integrated with a variety of design tools including Figma.

Useberry allows collection of rich insights and user feedback right from the prototype through a streamlined step by step workflow. During these tests, Useberry platform also allows collecting data such as session recordings, click tracking and user flows.

4. Results

Agilehand partners were invited to participate in the usability test of common platform. The usability test gave us insights into many useful findings. Leveraging the Metrics provided by System Usability Scale gave useful information to understand user behaviors. The feedback provided by participants was analyzed, focusing on metrics such as completion time, completion rate and user ratings. The following Figure 4 is a click heatmap of home page, giving insights on what parts of the page users expect to be interactive and should give users visual feedback when they click on it.

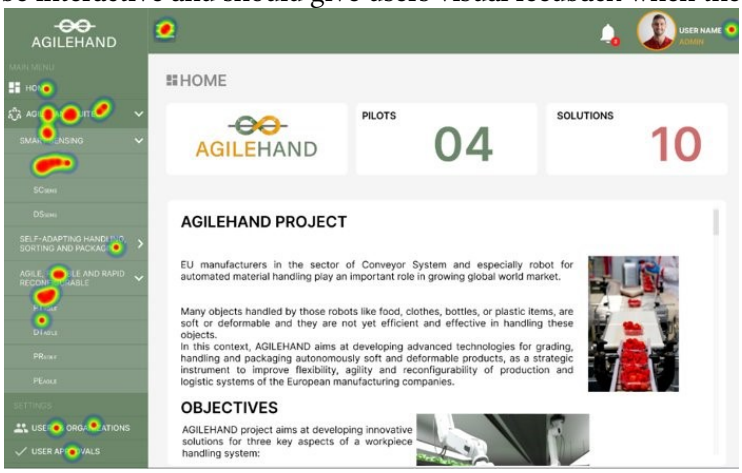

Figure 4: Users click heatmap on home page

Analyzing the user flows (**Error! Reference source not found.**) recorded during prototype navigation tasks for example in the task "Select GQ SENS solution from AGILEHAND SUITES" It is shown that users took different approaches to complete the task while majority of participants were successfully able to complete the task, some participants deviated to a different page and were not able to complete the task as described, which led to abandonment of the task.

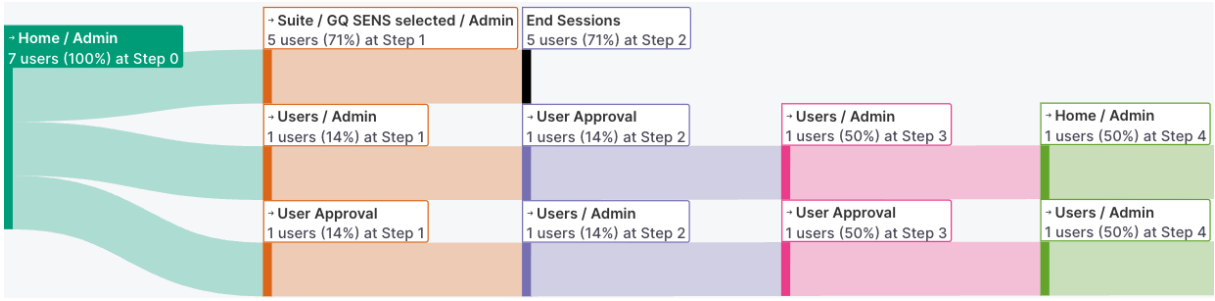

Figure 5: User navigation flows

Figure 6 shows the number of total attempts for each task in the Usability test. It can be observed that a maximum of 7 attempts were recorded for the first task which concludes that the task was completed by all the participants who attempted this task. Only task 2 and task 10 were not completed by 1 participant.

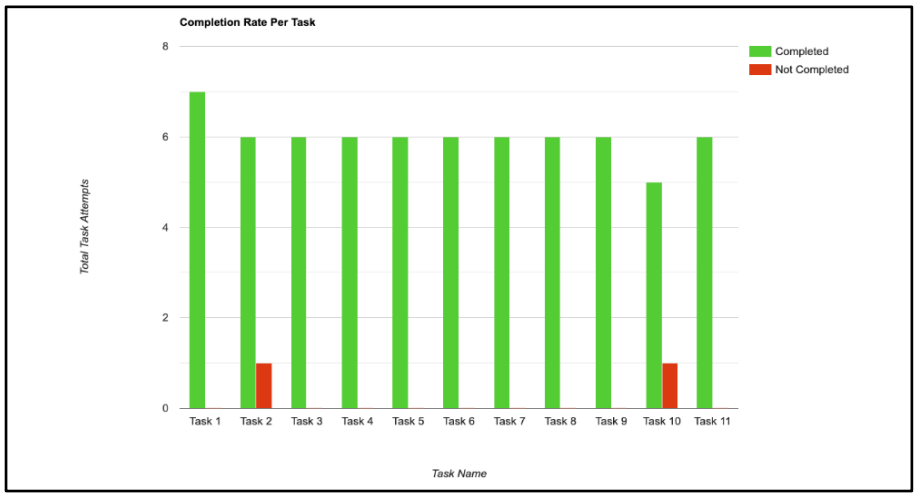

Figure 6: Task completion rate

The completion rate per task depicted in **Figure 6** shows cumulative attempts by participants during the usability testing process across various tasks. A prominent observation is that a substantial proportion of participants (i.e., 7) successfully completed Task 1, indicating that Task 1 was easy to accomplish, and instructions provided were comprehensible. Furthermore, it is worth mentioning that only two tasks (i.e., Task 2 and Task 10) did not meet full completion rate, highlighting potential issues that could be linked to task instructions or design elements.

Similarly, in **Figure 7**, the Average time of completion per task indicates that most of the tasks attempted took adequate time for most participants who completed the task. This metric indicates that completion time was within expected time intervals.

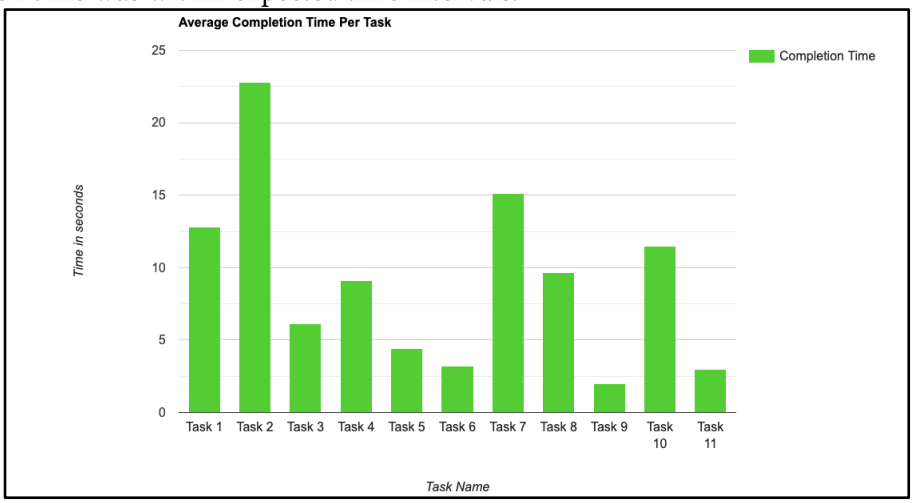

Figure 7: Average completion time per task

5. Conclusion

In conclusion, the usability testing revealed that overall proposed design has good user experience while there is room for improvement in parts of the design which users found unreachable or not interactable. In perspective of the future work, more research could be carried out on alternative navigation patterns or input methods for higher user intractability with the design components to enhance usability. Additionally, further rounds of usability testing could also be carried out with diverse user groups which could provide valuable insights.

This work highlights the results of AGILEHAND project that is directly relevant to the objectives of the workshop which aims to integrate innovative technologies such as AI, IoT, and data driven approaches in manufacturing. The workshop's primary objective is to foster knowledge sharing and collaboration towards creating efficient, resilient, and intelligent manufacturing systems. The proposed paper contributes to this goal, by developing a testing procedure to be used for validating and assessing the basics of AGILEHAND solutions functionality and increasing user-friendliness. Such solutions focus on smart handling technologies that improve efficiency and potentially resilience and intelligence in manufacturing and logistics operations. Moreover, both the workshop and the AGILEHAND project highlight the importance of cross-sectoral collaboration for advancing Industry 4.0. The proposed paper focuses on demonstrating the usage of AGILEHAND unified UI platform in four industrial pilots.

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Declaration on Generative AI

The author(s) have not employed any Generative AI tools.

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