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Ishii in [26] also mentioned that “tangible interfaces give physical form to digital information, employing physical artifacts both as representations and controls for computational media”.

This paper is organized as follows: in Section 2 we present a brief state of the art about dual reality, tangible interaction and some related works connecting HRI and tabletops. In Section 3 we expose our study design and it context. In Section 4 we discuss our ndings and their analysis, we also highlight the advantages of each interactio technique. Finally, we conclude in Section 5 by exposing our roadmap and what is next to do in this work.

2. State of the art

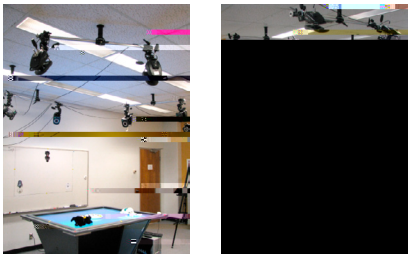
In this Section, we introduce the state of the art and some de nitions of Dual Reality, Tangible interaction on tabletops and Human-Robot collaboration. It is structured in three subsections as follows.

2.1. Dual reality

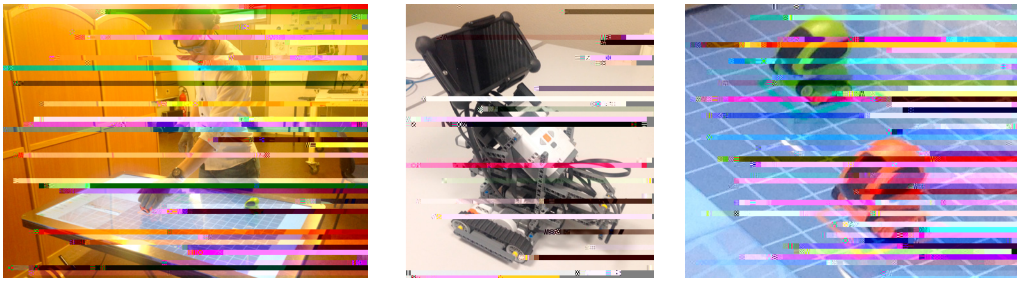
The term “dual reality” has been rst introduced in the Ph.D. thesis of J. Lifton [14] where he de nes the dual reality as “an environment resulting from the interplay between the real world and the virtual world, as mediated by networks of sensors and actuators. While both worlds are complete unto themselves, they are also enriched by the ability to mutually re ect, in uence, and merge into one another”.

Raber et al. [20] replicated a realistic task from retail domain, namely that of shelf planning, where retailers have to plan and organize their shelf layouts to optimize their pro t. They have designed the same real and a virtual environments where real and virtual products could be placed at arbitrary positions on the respective shelves in a she unit. Both environments can in uence each other and are always synchronized in the Dual-Reality condition.

In [18] authors show several examples of dual reality paradigm applications, realizing abstract models implying to cross the valley separating the abstract conceptualization and its actual completion in the physical world. The In 20 examples depict how the concept of dual reality can be used in di erent domains, including applicationsn res amels -



(a) (b)



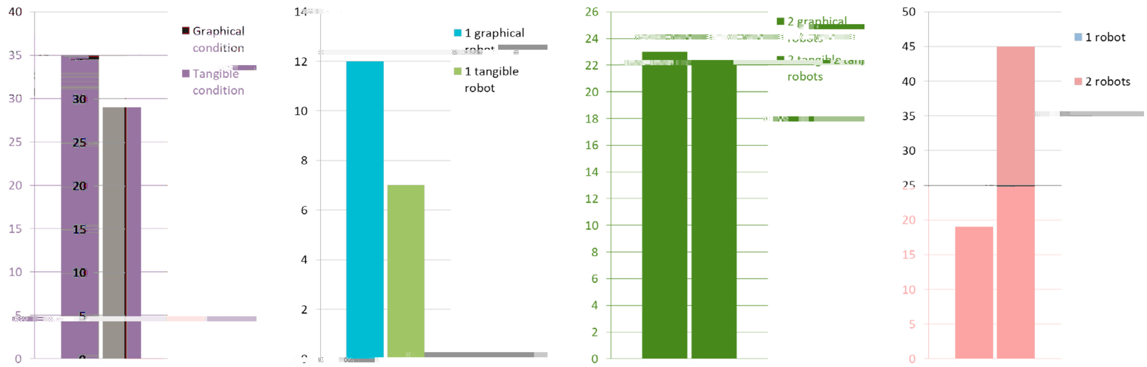
(a) (b) (c)

Fig 2: (a) A [illegible] (b) L [illegible] (c) [illegible] RFID [illegible]

3.1. Participants

[illegible] 32 [illegible] (9 [illegible], 23 [illegible]) [illegible] PhD. [illegible] [illegible] 22 to 39 [illegible] M 27.97 and SD 4.28, [illegible] mental demand, physical demand and temporal demand of the task, their performance, effort and their frustration. When finishing the two tasks in a given system, participants evaluate its usability by filling in a SUS questionnaire, containing the 10 standard questions [2]. We calculated the global score for each participant in each system, then based on these scores we calculated the means and the errors' ranges. The global score of a given participant is obtained as follows: (1) for each of the odd numbered questions, 1 is subtracted from the scores. (2) For each of the even numbered

Since the Pearson's correlation coefficient (r) is between 0.3 and 0.5, we can say that the effect size is from medium to large. Note that the conducted [illegible] is one-sided because we were expecting that the scores are quite different.



(a) (b) (c) (d)

Fig. 5: (a) Sums of errors in Tangible interaction and in Tactile interaction techniques. (b) Sums of errors when using one robot in tangible interaction and in tactile interaction techniques. (c) Sums of errors when using two robots in tangible interaction and in tactile interaction techniques. (d) Sums of total errors when using one robot and when using two robots, regardless of the interaction technique.

4.4.

Using the errors committed by participants, we could come out with completion rates of tasks. We proceeded as follows for each task: if the participant does successfully complete a task then we assign 1, if s/he does not then we assign 0. At the end and for each task we sum up the scores assigned for each task and divide the sum by the number of participants (32). Figure 6 signi cant. Meanwhile, we have seen the di erences between the tangible interaction and the tactile interaction techniques in usability and in terms of committed errors in favor of tangible interaction technique. Although the studied scenario is simple, the empirical results of this study suggest a tendency towards improving the user performances an user experience when using tangible interaction. Such bene ts could be useful in situations where users work unde pressure and are stressful, such as crisis management application [6]. In the near future, we aim at analyzing furthe data of the experiment such as the reaction times, further investigate the interplay between workload and tangibl interaction and do more experiments on di erent levels of complexity of tasks in dual reality. We also plan to explore the advantages of TUI systems on human-human cooperation with more demanding and more stressful scenarios f stakeholders of crisis management and in other domains such as design and education.

References

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[4]