

Comments and Responses

In the following paragraphs, comments of the reviewers are presented in gray and the responses in white. You will also find a pdf with all changes of the original manuscript marked (Track changes was activated) and a small comment that associates each change with a specific comment of one of the reviewers (e.g. if you see R1.Q1, the change in the document results from Reviewer 1, Question 1). We have also prepared the final manuscript in the PCI Journal format.

We would like to thank the reviewers for their valuable comments. We have tried to address all comments and to our opinion the paper has been significantly improved. So, once again, we would like to thank the reviewers. As a general comment, we would like to state that this paper presents a summary of technical and practical achievements – each of which is presented analytically in a separate technical paper. As a result, the specific paper appears “brief” and with many “missing” details. Nevertheless, the review has given us a guide to complete this puzzle in some directions, making the final paper more meaningful. So, thanks once again for the comments.

Review by Dominik Haggmann, 12 Aug 2023 18:02

Review on "Exploiting RFID Technology and Robotics in the Museum"

The paper details the outcomes of a project co-funded by the European Union and Greek national funds, focusing on the integration of advanced technologies in the field of cultural heritage. The primary technologies explored include the Internet of Things (IoT), Robotics, Big Data analysis, and Artificial Intelligence (AI), with a particular emphasis on RFID (Radio-Frequency Identification) technology.

The paper's content is unusual since it has not been segmented into traditional sections like "Introduction," "Methods," "Results," etc. Instead, the text is structured around specific topics, references, and other details.

Overall, the paper contributes valuable insights into the ongoing conversation around technology's role in preserving and enhancing cultural heritage. It serves as an exemplary model of how interdisciplinary collaboration can lead to innovative solutions and offers inspiration for future projects in this domain.

Nevertheless, I think some points should be addressed, which cover essential aspects of the paper, ranging from practical concerns to ethical considerations and technical details:

R1. Q1. Long-term Availability and Updates: What is the long-term availability of the systems implemented in this project? How often will updates be required (and available) over the next 10 years to keep the systems up to date?

R1.Q1. It is hard to foresee the necessary updates over the next years. As far as the RFID systems are concerned, the equipment is not expected to need replacement/repair for the next decade; perhaps the small micro-computers connected to each reader, might need repairs, but at low-cost. As far as the robot is concerned, battery should be replaced regularly; perhaps annually or bi-annually. Apart from that, the

remaining hardware (i.e. motors.) we can't estimate for sure, as this is a prototype. The financial model for sustainability of the products (of this project) is to spend part of the revenue from the project's applications to support them.

R1. Q2. Impact on the Labor Market: What is the impact of such digital systems on the labor market, particularly in museums and cultural institutions? Considering the current discussion around AI, mostly with regard to large language model-based chatbots like ChatGPT (although I'm aware that such things are not discussed in the paper), it would be interesting to address the question: may this technology be perceived as a threat or support to employees? E.g., there has even already been some feedback from the museum, etc. - if not, a general assessment would certainly be sufficient.

R1. Q2. Digital guided tours are expected to have an impact on physical-guides. However, such tours exist, in different forms, the last 3 decades. Therefore, it seems that some people prefer a human-guide, while others opt for the digital world. Artificial Intelligence, with its latest updates exhibited in large-language model-based chatbots, will possibly affect museum's personnel; tasks like information, or monitoring could perhaps be addressed by technology. It seems reasonable to predict a reduction of museum's personnel; at least people related to the monitoring and safe-guarding of the museum.

On the other hand, support for the new digital systems, necessitates the recruitment of IT personnel in museums, capable to understand, administer and update such systems. At least, this is the case in the systems shown in this paper. Part of the income from the new applications (location-based guided tour, robot-rental) is spent on new personnel, specialized in Information technology.

R1.Q3. GDPR-related Measures: Do the GDPR-related measures described in the project also apply to the personnel within the museums or cultural institutions? Why or why not? What are the legal and ethical considerations in implementing these measures in the context of personnel?

Currently, usage of RFID tags is optional to the museum's personnel. The system has been designed to monitor movements of exhibits and support "prior" labor-work carried out by such personnel (they had to take notes on such necessary movements of artifacts). So, only personnel, associated with these movement of artifacts is forced to use RFID tags, during such movements. Related personnel has embraced the technology, as it has simplified related work; information related to each movement is automatically stored in the database, while personnel simply writes a short text, describing the reason for the movement (this text is stored and accompanies the artifact in its digital history).

We don't know the possible legal or ethical constraints, associated with a possible mandatory use of RFID technology, capable of positioning to the related personnel. My opinion is that such technology should be used for addressing specific problems in the museum's work-flow, as used herein, and not for "controlling" personnel.

R1. Q4. Machine Learning Algorithms: The paper briefly mentions machine learning algorithms used in the project. Could you provide a more specific description of the techniques and methods used, even if only in one or two sentences?

If these points could be addressed in 1-2 sentences each, this would indeed help to clarify the questions at hand and may help to strengthen the paper (at least I hope so).

R1. Q4. We have used the RASA open source conversational AI platform. We have designed our conversational model, including “intents” and “entities” and then trained the model to accept possible questions and be able to engage in a discussion related to the trained information. We have also designed another solution, not yet demonstrated to the public, capable to deliver information, related to **all** exhibits of the museum, allowing the conversational agent running on the robot to have access on the information, already stored in the database.

Anyway, I think the paper should definitely be accepted!

Thank you very much.

Review by Alexis Pantos, 16 Oct 2023 08:56

R2.Q1. This is generally well written article with an ok structure and description of the work. It attempts to accommodate a large body of work and makes good use of earlier publications to direct the reader to additional detail. The description and title are appropriate to the content and the authors show an awareness of similar efforts to apply RFID tags within a museum context. Some aspects of the text might benefit from rephrasing or reduction to improve flow and clarity. Conversely some elements might benefit from additional clarification or identification of future work. For example the article could be strengthened by including a discussion on how the success of the robot prototype has been, or will be measured.

R2.Q1. Really good point. We have included such a discussion in the newly added section (former “Conclusions”). The robot and the RFID-reader have been included in the museum’s “booking” program since February 2023 and we requested from students (for the games) and visitors (for other apps, including discussion with the robot) to fill a questionnaire in a “google form”, immediately after the interaction. We have now introduced some representative results.

R2.Q2. The references include a mixture of academic articles and relevant popular media references which helps to contextualise the current project well, however the referencing style changes throughout the body text and should be standardised. The body also includes multiple references lacking the a,b,c. suffix present in the reference list.

R2. Q2. The paper was submitted to a conference, adopting the conference-style submission. It has now been edited to the journal-style manuscript; though in the “track changes” version you won’t see the correct format.

R2.Q3. Figures are relevant to the text, but some may be better presented as compound figures with sub-elements (e.g. a,b,c) and referenced from the body text.

We have changed numbering as recommended and adopted this suggestion in the newly added figures as well.

R2.Q4. Overall this appears to be an interesting project that could benefit from some minor adjustments to the text and some additional clarifications. Further comments and suggestions are included as tracked changes along with this review.

Review by Sebastian Hageneuer, 25 Sep 2023 18:45

The article has an interesting topic: RFID technology inside a museum to help the staff and visitors as well as a social robot that offers guided tours for adults or quizzes for the younger audience. Although the premise of the article is pretty interesting, the article itself is way too short and leaves a lot of questions open.

R3. Q1. In the beginning, several museums are listed, that already use this technology. Without reading the cited book, I can not understand in which way their use differs from the use described in this article. A closer discussion of the presented examples would help to better understand what is new here in the CultureID project

- The same goes for the examples of the social robots. So summarizing with the previous point, the introduction needs to be more extensive and informative to the reader. Also why does the CultureID project exist? What problem is tried to be solved?

R3. Q1. We have added two separate paragraphs in the Introduction. CultureID addressed several “problems”, to the best of our knowledge of great interest to museums, namely: 1) Control and automatic digital storage of “interventions”/“participation in exhibitions”, etc. on the artifacts, through monitoring of their movements (typically an artifact is moved when something has to be done on it, 2) monitoring of statistics, related to the interest of visitors, 3) gamification of the experience of visitors, 4) provision of location-dependent guided tours.

R3. Q2. Section 1 is merely a paragraph and does not explain the technology sufficiently. What are the problems with RFID technology? Are there any security risks, for example if I bring my own RFID reader/writer? What is the environmental impact of using these chips?

R3. Q2. You are right. We have merged Section I with Section II, under the title of Section II, i.e. “Exploitation of RFID technology”. Now the 1st paragraph makes more sense to give a short description of the technology, followed by the ways that we have exploited it. We understand that you need more details in each subsection. However, as commented in the introduction of this document, “we would like to state that this paper presents a summary of technical and practical achievements – each of which is presented analytically in a separate technical paper. As a result, the specific paper appears “brief” and with many “missing” details.”

Each RFID tag is locked and cannot be reprogrammed by an external RFID reader. Even if a tag is interrogated, the related information in the database will not be accessed. The tags represent the keys to information, provided that the computer (that uses those keys) has access to the database. (this text has been added in the manuscript)

It is reminded that the technology does not affect the security of the museum. It is used for improving processes and to deliver new applications that enhance the experience of visiting the museum and could increase profit. The tags are not “stuck” to the exhibits; they are tied by means of a string (with the exception of statues). So, they can’t be used for security, given that one could cut the string and de-associate the tag from the artifact.

R3.Q3. Section 2 is quiet interesting, but I would like to learn more about the restrictions of RFID when attaching it to artefacts in the museum. The article metioned that it is difficult with metallic material. Why? Are there any solutions or did you just not attach a chip on metallic objects after all?

R3.Q3. Metallic materials affect the equivalent impedance of the RFID-tag’s antenna. As a result, the tag’s antenna (when close to a metal) does not transfer the same amount of power to the tag’s integrated circuit as in non-metallic materials and/or could even fail to deliver any power at all. So such a tag would not be identified by the RFID reader. There are two ways to avoid this issue: 1) buy an RFID tag that has been designed for application on metal (the tag’s antenna is designed to work on metal), 2) use a dielectric material surrounding a typical tag, so that its antenna will never operate in close proximity to the metallic surface (it’s what we have done in prior work - Dermenoudi et al). We opted for the 2nd way due to the related smaller cost. Again, details are given in our prior work.

R3.Q4. Coming back to the point of the environmental impact of these chips in visitors tickets. Where there any discussions about this? Is there a way to properly recycle these tickets? Can you tell us more about the app, how it functions and what one can do with it?

R3. Q4. The tickets are being re-used. Each client receives an RFID badge and returns it to the entrance. We have prepared 300 RFID-badges, a total population that exceeds the number of concurrent visitors.

We have added a photo and special reference in the corrected manuscript, in the “Discussion Part”, under GDPR related measures.

R3.Q5. Also the statistics are very relevant, but we do not learn anything from it. Did they have any impact yet and if yes, which ones? What is expected from collecting these statistics?

R3. Q5. Administration of the museum collects and monitors the statistics. The statistics currently demonstrate the time spent in each part of the museum. Such information is useful to decide whether parts of the installation appear more interesting to the visitors. Then the museum should decide whether to replace artifacts with others or to re-arrange exhibits in the exhibition.

R3. Q6. Section 3 more or less omits readable text and utilizes bullet points, which - in my opinion - are not suitable for a scientific paper. Again, further questions arise. What was the experience of the users with the robot? What happens if multiple people try to talk to the robot? How long does its battery last, can it speak multiple languages? How do "discussions" with adults look like? What are the benefits?

R3. Q6. The experience of the visitors with the robot is now presented in the manuscript in the updated “Discussion” section, where rating from visitors is included in the results (by means of questionnaires given in google-forms).

The robot does not “filter” voices but rather listens to anyone. If they speak at the same time, it would probably fail to understand anyone. However, our experience showed that when one talks, others “passing-by” stop to listen. They do not engage in the conversation, but rather enjoy the experience as co-listeners to the person that has started the conversation. There is a “demo” video, which is not from an actual unknown visitor, but shows the concept, while of course the audio is real (it is not fake): <https://www.youtube.com/watch?v=mrTL3Gep7Xk>. We have inserted the video link in the references, accompanied by related text in the manuscript. Also, whenever possible, we added more details in the descriptions of (former) Section 3.

R3. Q7. Section 4 is again too short. The conclusion of a research paper is where you wrap up your ideas and leave the reader with a strong final impression. It has several key goals: 1. Restate the problem statement addressed in the paper (there was no problem to begin with), 2. Summarize your overall arguments or findings (this was done, albeit way too short), 3. Suggest the key takeaways from your paper (missing).

R3.Q7. Section 4 has been renamed to Discussion and includes many key-points from the above comments as well as results of the reception of the robot and the guided tour from the visitors.

To summarize: I think the topic of the paper is very interesting and clearly the project has done a lot of good work to make this possible and running. Unfortunately, the quality of the paper needs improvement.

We would like to thank you for your effort. We believe to have changed the manuscript extensively to address all comments. We feel it has been greatly improved, thanks to the revision process.