University of York

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Research Proposal

Ethical, security and privacy concerns faced by the implementation of Large Language Models (LLMs) in Human Robot Interfaces (HRIs)

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Contents

1 Introduction

1.1 Identification and Justification

1.1.1 Topic/Research object

A topic is an area that is to be researched[1]. The topics for this research are security, privacy and ethics as well as software design and implementation.

1.1.2 Unit of analysis

A unit of analysis is the entity that is the focus of the research[2]. Here, there are two units of analysis to consider: The LLMs and their potential use in HRIs; and the end-users and their desires, assessed via interviews and surveys.

1.1.3 Justification

Concerns over existing privacy and security capabilities of LLMs have been expressed[3][4][5][6]. Furthermore, various ethical dilemmas have been raised with few existing regulations to mitigate against them[3][5][7][8][9]. It is interesting to note however, that an HRI with LLM capabilities is scheduled to be released by the end of 2024: MenteeBot[10][11]. Yet, there is little mention of security, privacy and ethical considerations on the MenteeBot website. Are these features being implemented by the manufacturer? How will they ensure that the robot cannot cause harm either inadvertently or via malicious agents? This research would aim to address the potential gaps identified here .

1.1.4 Aims and objectives

This study will complete a literature review; gain an understanding of ethical requirements; implement an example program to demonstrate potential responses to ethical considerations; and write up the findings in a report.

1.2 Research Questions

For mixed methods studies, specific mixed method questions are desirable[12]. It is expected that central question 1 (below) will be answered through literature analysis. However, some information may be gleaned through interviews and surveys. Central question 2 is the main mixed methods question and addresses both qualitative and quantitative areas of the research[1].

Central question 1: To what extent can existing frameworks and regulations for security and privacy be applied to the use of LLMs in HRIs?

Sub-question 1: Which of the existing regulations are relevant to this scenario? For example, should GDPR be considered for privacy issues[13]?

Sub-question 2: Are there additional considerations not in existing regulations that are required?

Central question 2: What ethical capabilities would end-users expect from HRIs?

Sub question 1: Which ethical capabilities might users prioritise: Transparency? Fairness? Accountability? Something else?

Sub question 2: Can software be developed to take ethical considerations into account for the actions of an HRI?

2 Literature Review

As noted in section 1.1.3, concerns over the core issues identified have been expressed in the literature. Kumar's 2024 study confirms that vulnerabilities in security of LLMs continue to be concerning[6]. He studies works on LLM security and presents an overview of current frameworks[6]. He concludes that more research needs to be carried out - particularly in terms of how efficient attacks on LLMs are likely to be as well as the scale of these potential attacks[6].

Gupta et al. also express concerns over privacy and security. They explain that, due to the vast amounts of personal information contained in the datasets used to train LLMs, there is a possibility that this information could be inadvertently divulged[3]. However, they introduce new techniques in cryptography and authentication to enhance security in LLMs as a means to combat this concern[3]. Huang et al. express similar concerns over privacy and security [4]. Their issue with security in LLMs stems from the aging of LLMs and their future ability to cope with the evolution of malware[4]. Their solution is to design 'EvolveDroid' which aims to evolve malware detection systems for LLMs in line with the evolution of malware[4].

Therefore, it can be seen that approaches to tackle the security problems are already being undertaken. But what of the users' choices about what personal information is allowed to

be shared? Users should have a right to say how their data will be used[14]. And, do organisations that currently use LLMs fall foul of regulations such as GDPR designed to protect privacy[13]? Certainly, lapses in privacy have already happened. OpenAI had to disable ChatGPT in March 2023 because some chat history information was inadvertently shared[15]. However, this appears to have been the result of a bug rather than any adversarial attack[15]. Therefore, as far as privacy and security is concerned, efficiency and scale of cyber-attacks would seem to be a key area for further research[6].

This then brings us to ethical concerns expressed in the literature. Bugs in code and security breaches can both lead to ethical issues. This is before unforeseen circumstances are even considered. Liu et al. look at ethical and security considerations by adjusting inputs to an LLM in order to create false predictions[5]. They use the corresponding results to study ethical and security issues[5]. Their 2024 study notes that evaluations of ethical and security concerns of LLMs are '...still in their infancy'[5]. They also state that prejudice and discrimination are ethical problems present in LLMs[5]. Cabrera et al. go further and identify '24 moral dilemmas' in the use of LLM chatbots, albeit specific to the field of mental health[8]. Their 2023 study reviewed the literature to identify issues with care, access, responsibility and regulatory concerns[8]. However, many of these core issues would be applicable to all LLMs, and in particular, their use in an HRI. Casheekar et al. confirm the possible use of chatbots in physical robots in their 2024 study[9]. Their work studies the literature, provides some background information on chatbots and includes an analysis of user interfaces for existing chatbots[9]. They go on to state that discussiona on ethical and regulatory issues are lacking in the literature[9].

There are also cultural implications to be considered when discussing ethics. Schenck discusses Power Distance - a cultural measure for determining the level of equality between the

author and the reader[16]. He explains that some languages naturally require more persuasive language in writings than others[16]. The resulting difference in language might lead some cultures to question what is written when others would not[16]. Schenck arranged for 200 essays to be written by humans and compared with 200 essays on the same topics written by ChatGPT. He concludes that ChatGPT is not aware of Power Distance, potentially due to biases instilled in the training process[16].

There are further cultural differences apparent when we consider emotions. Several works raise the question of emotional intelligence in chatbots - specifically its importance, and whether they posses it[17][18][19]. With 40% of user interactions being emotional[19], emotional intelligence is an important topic. Bilquise et al. state that chatbots are already used to give emotional and social support[18]. In their 2022 work, they review research on chatbots that possess emotional intelligence and explain that communication can only be effective if emotions are understood[18]. They find that Chinese language chatbots have the greatest number of interactions in developing emotional intelligence[18]. It would seem that other cultures have more work to be done in developing emotional intelligence in AI.

Interestingly, none of the reviewed papers question if these chatbots SHOULD have emotional intelligence. What kind of responsibilities should we allow AI systems? The literature cites such existing and future uses as:

- Autonomous vehicles[7]
- Finance consulting[20]
- Medical consulting[20]
- Legal consulting[20]

- Counsellor/Mental Health[20][8]
- Carebots[7]
- Teacher[21]

Would implementation of the above in an HRI cause any unforeseen issues? The reviewed literature does not discuss this. Furthermore, it has not discussed such classical ethical decisions as the runaway tram problem devised by Philippa Foot[22]. These problems surely become more significant in an HRI, but none of the papers reviewed discuss it. This would seem to indicate an area for further research.

With all the concerns raised, Dubljević proposes a partnership between universities and industry to guide security and ethical considerations[7]. His 2024 work warns against 'alarmist thinking' but urges the introduction of regulations to avoid harm and yet still provide the benefits of this technology to everyone[7]. He proposes this new technology be initially limited in its use to enable correct policies to be implemented before it is made widely available to all[7]. One cannot help thinking though, that his proposal has come too late since this technology is already widely available. Could its sudden removal from wider society cause more harm than good? What of all the individuals that use AI for emotional support discussed previously? What harm could it do to them if it were removed? Or is using a machine for emotional support a problem in itself? These are more questions worth considering for further research.

3 Methodology

3.1 Research Philosophy

The research philosophy identified here is that of a pragmatic worldview[1]. A pragmatic worldview deals with implications of the result of actions, is focussed on problems and is concerned with real world practice[1]. From the research questions, it can be seen that this research:

- deals with the consequences of the action of implementing LLMs in HRIs.
- is focussed on the problems of security, privacy and ethical controls in this implementation.
- will generate results applicable to the real-world scenario of an HRI.

Therefore, this research matches the criteria for a pragmatic worldview identified by Cresswell[1].

3.2 Research Methodology

The research methodology falls into a sequential mixed methods category[1]. For the user analysis, the interviews and worded sections of the surveys are qualitative in nature, whilst the analysis for the multiple-choice sections of the survey will be quantitative[1]. The results from the surveys and interviews will feed into the design of the software for the HRI. This confirms the research to be mixed methods[1].

For the software development, an evolutionary prototyping approach will be used[23]. This is where a prototype develops into a final product. This approach is useful when there are uncertainties in the requirements of users[23], as will be the case here when the software development process begins.

3.3 Research Methods

3.3.1 Gather Data

Participants will be identified, and data will be collected using interviews and surveys[1]. Whilst there are disadvantages to this approach such as the researcher's presence in an interview providing bias, the advantage is that the researcher will directly control the questions being asked[1].

3.3.2 Analyse data

Across interviews and written responses in surveys, common themes will be coded to enable analysis of the most prominent requirements for ethical design[1]. Then, along with tick box responses, rudimentary analysis of the results will be carried out in order to identify the most crucial ethical requirements for the HRI. The approach here is discussed further in section 4.3.1.

3.3.3 Interpret data

To interpret the data, repeating patterns will be sought in the data to identify important phrases[24]. There will also be value in the information gained from the literature as well as the researcher's own personal experiences[1]. The quantitative data from surveys will be interpreted using the charts created in the analysis phase. Following this, the resulting strategy will use grounded theory to provide a general view of the ethical interactions required of the HRI[1].

3.3.4 Design program

The proposed approach for the HRI design is to use LangChain[25] and Python[26] on a Raspberry Pi[27]. This would use natural language inputs to control a simple motor designed to simulate actions taken by a robot. Then, an example implementation of ethical considerations within the system would be demonstrated. The details behind the choices made for this design are discussed in section 4.3.

4 Project Management

4.1 Project Plan

Dawson gives guidance on planning projects, indicating six key phases in the planning process which are followed here[23].

4.1.1 Work breakdown

Work breakdown structure is the process of breaking a project down into component tasks[23]. The tasks for this project are shown in figure 4.1 which has been created taking inspiration from Dawson's model[23].

4.1.2 Time estimates

In line with Dawson's design[23], Table 4.1 gives estimates for the duration of each activity identified in the work breakdown.

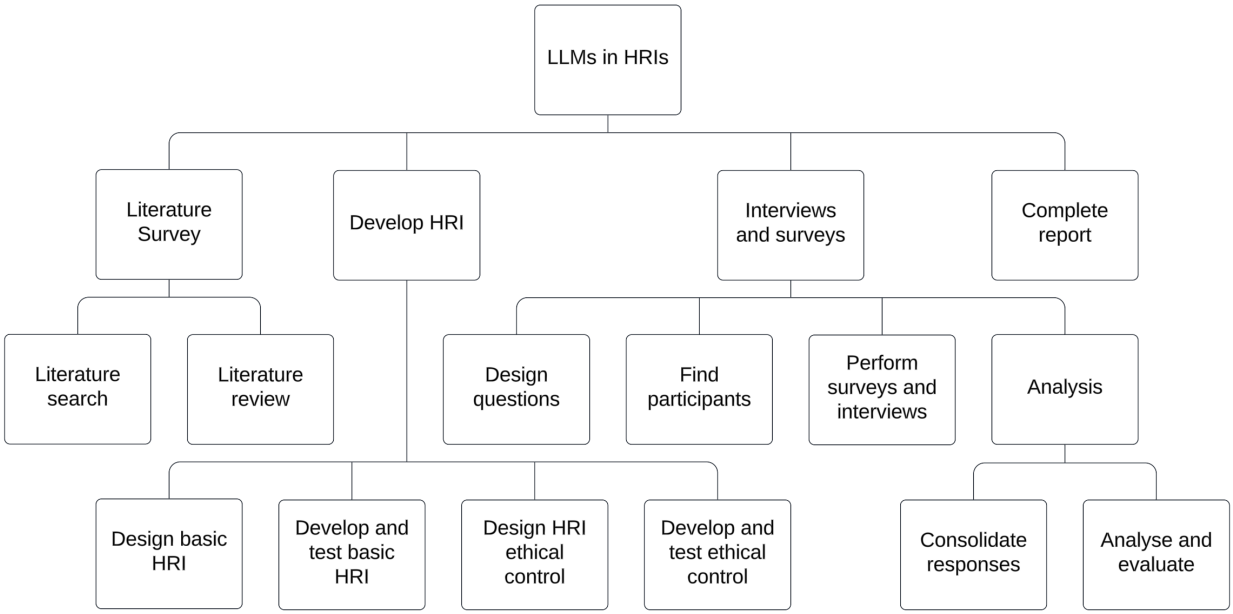


Figure 4.1 Work Breakdown Structure

Activity	Duration
Literature search	2 weeks
Literature review	1 week
Design basic HRI	1 week
Develop and test basic HRI	2 weeks
Design HRI ethical control	1 week
Develop and test ethical control	2 weeks
Design questions	1 week
Find participants	1 week
Perform surveys and interviews	2 weeks
Consolidate responses	1 week
Analyse and evaluate	1 week
Complete report	3 weeks
Total Effort	18 weeks

Table 4.1 - Estimations of task durations

4.1.3 Milestone identification

Milestones are key activities that are worthy of acknowledgement upon completion to help recognise progress through the project[23]. The milestones identified here are:

- Complete literature survey (M1)
- Complete interviews and surveys (M2)
- Complete development of HRI (M3)
- Complete report (M4)

4.1.4 Activity sequencing

Activity sequencing is the process of correctly ordering tasks[23]. Appendix A shows an activity network for the tasks identified for this project. As with Dawson's example, the critical path is denoted by thicker arrows[23].

4.1.5 Scheduling

The process of scheduling moves beyond activity sequencing and identifies tasks that will happen concurrently[23]. Appendix B shows a Gantt chart for the overall project across the 16-week period. The hatched region represents the slack time during the development of the HRI.

4.1.6 Re-planning

What is described in the plan is the final outcome of each stage following any adjustments made at each phase as discussed by Dawson[23]. In other words, the re-planning phase has already been applied.

4.2 Evaluation of plan

Overall, whilst the plan was created following Dawson's six key phases[23], there are potential issues with the scheduling of tasks. Most notably, the first two activities in the design of the basic HRI are scheduled to coincide with the literature survey. These activities are independent of each other, however, in practice it is not possible for one person to work on both simultaneously. It is likely that this schedule will fail from the outset as a result.

Another cause for concern is the lack of space in the schedule for items to overrun. There is no allowance for any unforeseen circumstances such as illness which can hinder progress on

a project[23]. Considering these factors, there is a strong argument for reducing the number of activities to be carried out. This is discussed further in section 4.4.

4.3 Computational Approach

The plan for implementing the HRI has been described in section 3.3.4. In the field of computer science, this approach would fall under advanced programming. This section will discuss the justifications behind these implementation choices, as well as the computational approach to the data analysis.

4.3.1 Data Analysis

It is envisaged that simple presentation of results in bar charts using software such as SPSS will suffice in identifying these requirements.

4.3.2 Raspberry Pi

A Raspberry Pi is an inexpensive, yet high performing, single board computer[27]. Other systems suitable for controlling electric motors were considered. These are described below along with reasons for their rejection:

- BeagleBone Black - less community support available compared with Raspberry Pi[28].

- ESP32 or Teensy - less like computers and more akin to microcontrollers[29] which generally have slower CPU speeds[30]. Having the functionality of a computer is desirable for using LangChain.
- STM32 Nucleo Boards - Less appropriate for applications that require a high require a high communication bandwidth[31]. Whilst this may not be necessary for this application, in the future, the potential incorporation of cameras in the HRI may require the transmission of high bandwidth video.

4.3.3 LangChain

LangChain is a platform for making applications that can utilise LLMs[25]. The three main alternatives to LangChain that were considered, and their reasons for rejection, are described here:

- Auto-GPT - can become stuck in self-perpetuating loops[32].
- Flowise AI - does not offer the same level of customisation as LangChain[33].
- AgentGPT - currently only available in beta form[32][34] so there may be undesired functionality.

4.3.4 Python

Once the decision to use LangChain was made, the decision on which programming language to use was limited to a choice between Python and Javascript[35]. JavaScript is mainly

used to provide user functionality to websites via browsers[36]. This functionality is not needed for this application. Using Halstead Metrics, Python is a less complex language and implementation appears to be quicker as well[36]. For these reasons, Python was chosen over Javascript.

4.4 Risks, Limitations and Countermeasures

As discussed in section 4.2, there is a risk that the project could overrun in its current format. A proposed countermeasure would be to eliminate the interviews and surveys phase of the project and rely on the literature entirely to determine what is needed for the HRI. However, this would need to be discussed carefully with the project supervisor.

If the surveys and interviews are used, it is likely that the resulting data will be skewed towards western ideologies due to access limitations for other cultures. Therefore, the resulting application would be aimed at western markets rather than being fully global.

Risks for the computational approach are that it relies on the correct creation of bespoke hardware requiring specialised components. Whilst it is envisaged that the system will not be overly complex, the process of setting it up (as part of the 'develop HRI' phase) could result in some unforeseen delays. To mitigate against this, it has already been decided to use just one electric motor to simulate a robot action. The robot is not the main focus of this work - the potential actions it may take are.

5 Ethical Implications

The University of York outlines guidance on ethics[37]. The primary consideration is to avoid harm[37]. This research will consider the welfare of humans (including those conducting the research); responsibility towards cultures in which HRIs could operate; and the reputation of the University. Other considerations could be justified (e.g. environmental concerns[37]). However, this is suggested for future work. Ethical judgments will also be considered in accordance with the Chartered Institute for IT's Code of Conduct[38].

5.1 Considerations and Mitigations

Participants will be carefully selected to ensure appropriately diverse samples are used[1]. Results from responses taken solely from known extremist groups for example, would cause bias.

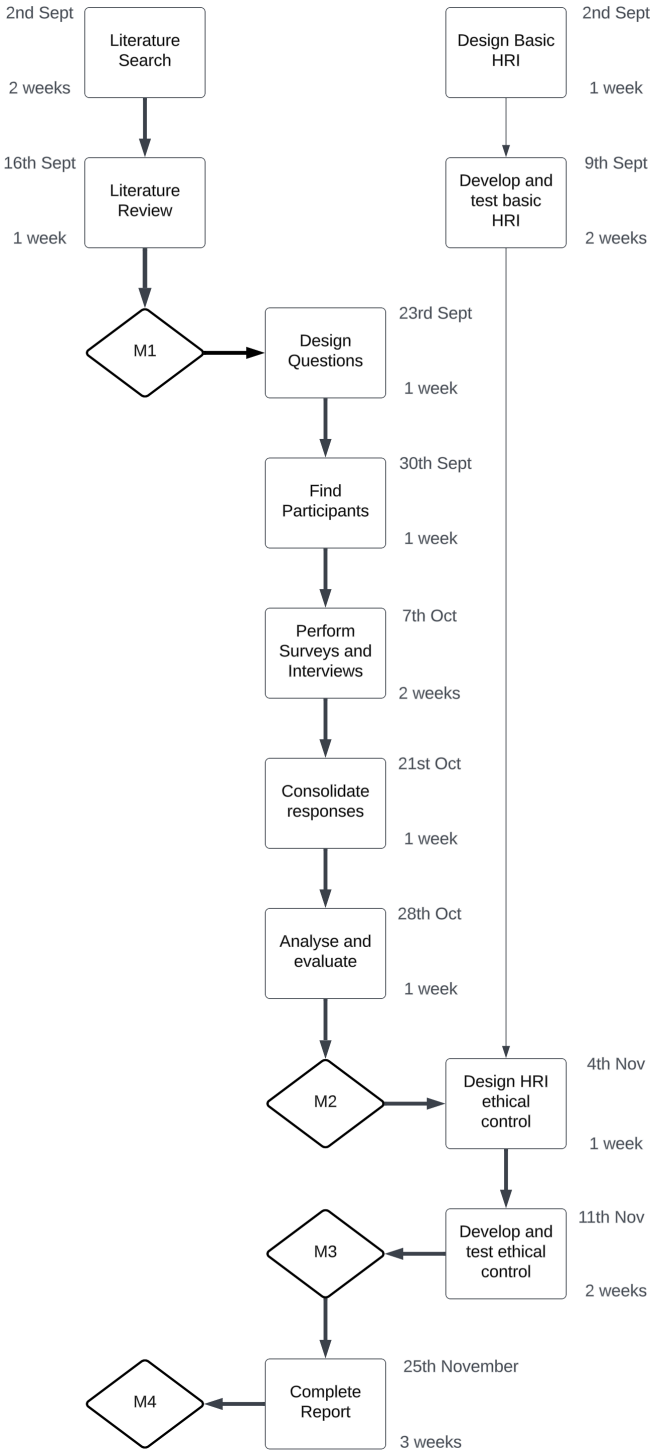
Participants could be psychologically affected by certain ethical scenarios. To mitigate against this, individuals will be warned, asked for consent, given options to stop at key points and be directed to resources to help with any resulting issues[37][38].

To ensure privacy[37][38], data will:

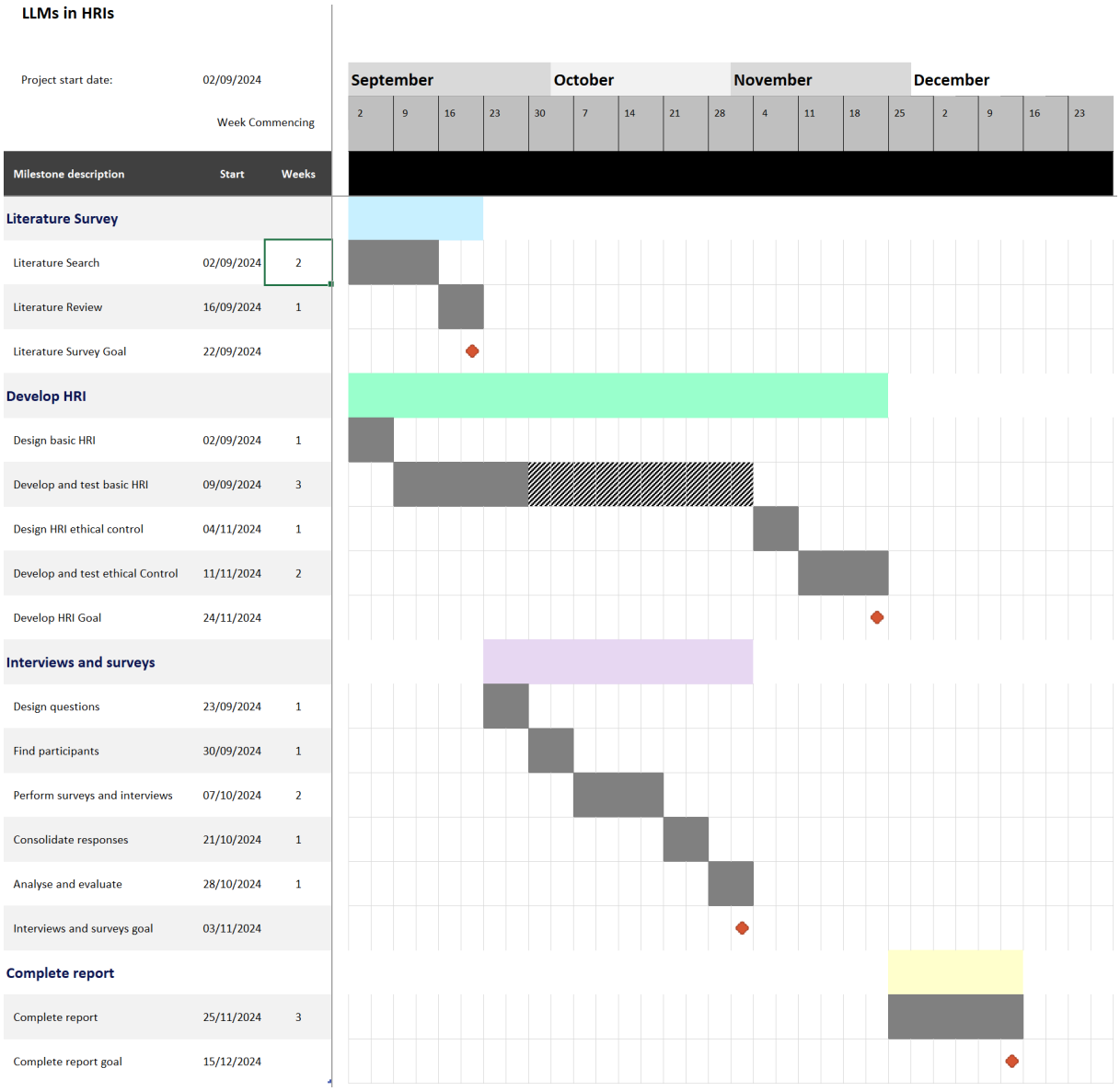
- be stored electronically
- not contain personal information
- be password protected

The research might lead to incorrect implementations of the application which could then cause harm. To mitigate against this, warnings will be issued explaining the software is an example of potential capabilities and should not be used in end products without adaptations.

Appendix A - Activity Network Diagram



Appendix B - Gantt Diagram for project plan



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