Ethical evaluation pertaining to using a deep learning framework to encourage the recycling of waste

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Abstract — Recycling of waste aids the attainment of environmental sustainability. The proposed deep learning framework in this research can potentially encourage the recycling of waste. Waste image datasets were collected for model training and a market research survey was conducted. Ethical implications as regards carrying out this data analytics research in the waste management domain were evaluated. Also, strategies were implemented in the research to ensure an ethical conduct. No ethical law was violated in the research, based on proper evaluation and good practice of ethical conduct throughout the research.

Keywords: Ethics, Deep learning, Recycling

I. INTRODUCTION

Recycling of waste is one significant method of waste management to attain environmental sustainability. Rapid urbanization has however contributed to the increase of waste being generated. Developing and under-developed countries are faced with the challenge of achieving this method of waste management. This challenge is mostly attributed to the lack of awareness and motivation of householders to be involved in recycling. In a report by L. Godfrey et al. [1], only 4% of household waste are being recycled currently, compared to an estimate of 70-80% of waste generated. The research "*a deep learning framework to encourage the recycling of waste"* is motivated by the need to develop a strategy to increase the engagement of humans in their contribution to waste sorting and recycling to attain a sustainable environment. Also, the market for smart waste management system is large and currently still on the rise. Therefore, this tends to benefit the application of the deep learning framework.

The objectives of the research included the design of a deep learning framework that combines a deep learning image classification model and gamification elements for waste management, evaluation of six trained models using *accuracy*, *loss*, *latency* and *size* for the selection of an ideal model for the framework and the implementation of the deep learning framework on a mobile device. This research also included a study conducted via a survey, to obtain markets perception of an intelligent waste mobile app developed with the framework to encourage householders recycling habit.

Some of the key aspects of the research included carrying out a market research survey and acquiring waste image datasets for model training. Specific strategies were implemented to ensure the research was conducted ethically. These include[1]:

- **Confidentiality**: Information about the respondents location (country) and response data were kept private and not shared publicly or with a third-party.
- **Informed Consent**: Full information was provided for participants of the survey to be informed before taking part in the survey.
- **Anonymity**: Personal data such as name, address, exact age, gender etc were not obtained to ensure anonymity. Respondents were only required to select an age range and specify their country.

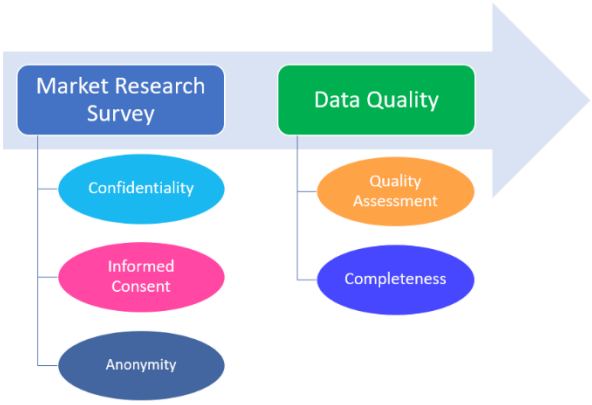

Fig. 1. Strategy implemented for Ethical Conduct

Fig. 1. Illustrates the strategy implemented for ethical conduct in the research. The sourced waste image datasets were assessed for data quality and completeness.

II. EVALUATION

Ethical issues which could possibly arise before, during and after the research were evaluated. These ethical issues and corresponding ethical principles are presented in three stages below.

1. Ethical issues and principles before research

Before commencing the research, checks were carried out to ensure no part of the research violated *copyright laws* and *user's privacy* or supported *plagiarism.* Deliberately, *confidentiality*, *informed consent* and *anonymity* were considered before and while setting up survey questions for the market research [2]. Likewise, checks were carried out on the waste image dataset and its source to ensure *data integrity*. The sources were open for use to the public and the datasets contained no sensitive information. Also, some ethical principles such as *Awareness* and *Accountability* [3] had to be taken into consideration at this stage, to ensure any potential harm was minimized. These principles demanded true understanding of the models to be applied and to give detailed explanation on each model and its result.

[1]S. Fisher, "Ethical issues to consider when conducting survey research", Qualtrics, 2020. https://www.qualtrics.com/blog/ethical-issues-for-online-surveys/

2. Ethical issues and principles during research

The research required the development and deployment of a deep learning framework for automated decision-making on waste classification via mobile devices. *Data inaccuracies* was constantly examined at this stage to ensure *data integrity*. Some ethical principles addressed here include: *Validation and Testing*. This meant carrying out multiple tests to ensure accuracy of the model used for the framework as well as precision of the configured game logic. Also, in terms of *confidentiality* and *data privacy* statistical analysis of the market research survey was carried out without disclosing respondents data. Another ethical principle addressed here was *Auditability* [4], which required keeping record of successful model inference. Experience points generated from the inference and its corresponding timestamp were saved for regulatory compliance.

3. Ethical issues and principles after research

Potential biases [5] were examined here to figure out next step for improvement in a future work. The principle of *Explanation* was addressed by ensuring a detailed step by step modelling process and application development was documented. In terms of *anonymity*, user's personal data were not required for the decision-making of the deep learning framework. As regards perpetuity of *data storage*, captured waste image data were discarded after inferences. *Data provenance* [3] is another ethical principle that was equally addressed by describing the method of gathering and processing the training dataset. Overall, the gathered dataset and its use did not violate any ethical laws. Likewise, the market research survey conducted, was carried out and reported in an ethical manner and with good practice of ethical conduct.

III. REFERENCES

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