23 LUSTRA (LUDIQUE SMARTRASH)

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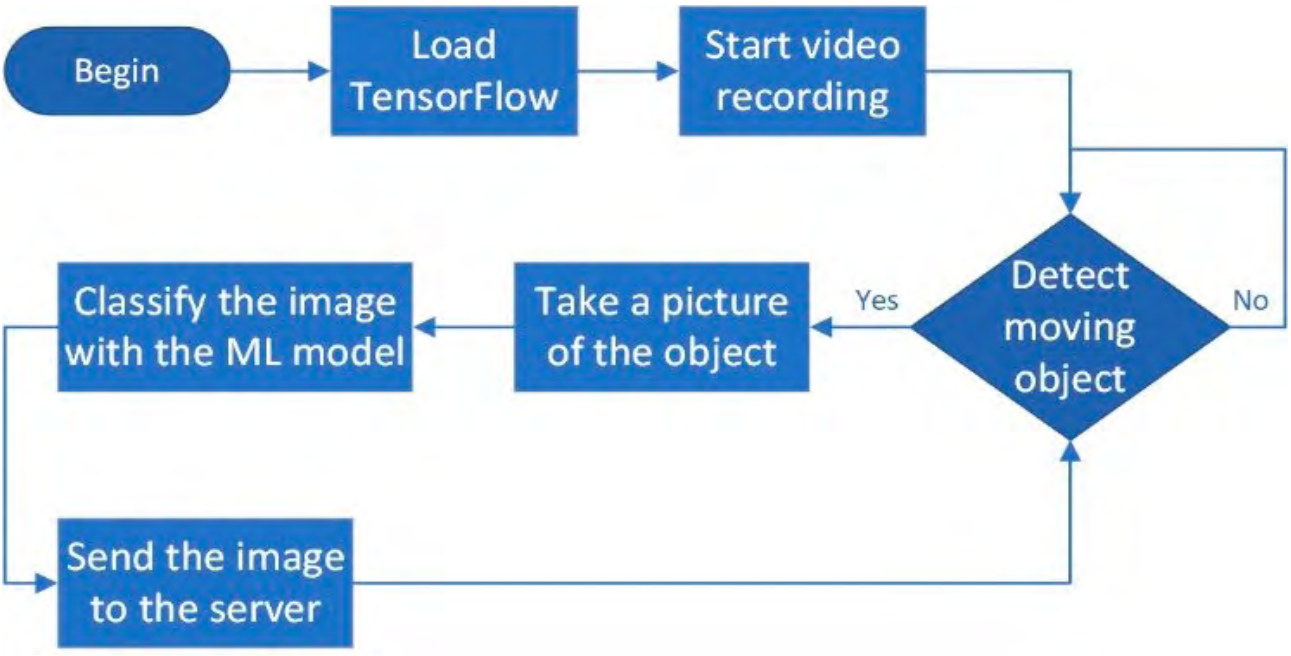
ABSTRACT

"LusTra" comes from "ludique" in French and "sorting Trash" in English. It is a motivating and playful sorting system to educate the young public to the right gestures; thus, recycling becomes a natural reflex thanks to an interactive and rewarding gamification system. We used machine learning methods to train models on the sensor data to recognize the waste types and return the information to the child via a playful interface. This is a real challenge when we know how difficult it is to differentiate Polyethylene Terephthalate (PET) from glass, as well as to detect paper. In this first stage of the work, we mainly focused on PET detection.

KEYWORDS

Gamification; IoT; AI, Machine Learning; Deep Learning; Image classification; Image recognition; Waste recycling; Waste sorting; Sorting system; PET.



CONTEXT

For some years now, the amount of combustible waste in Switzerland has not increased. However, the recycling rates of recoverable materials have reached a threshold due to an innovation and optimization lack. The amount of reusable waste can be recycled, thus helping to complete the material cycle, thus preserving resources and the environment. Despite the deployment of differentiated garbage cans, the quantity of not properly sorted waste is a real scourge and can still be reduced at the source. Eco-citizen behavior must be encouraged to banish persistent incivilities. This awareness concerns all the population whatever their social status or age. Therefore, we propose "LusTra", a motivating and playful sorting system, to educate the young public to the right gestures; thus, recycling becomes a natural reflex thanks to an interactive and rewarding gamification system. Machine learning (ML) methods are used to train models on the sensor data to recognize the different waste types and return the information to the child via a playful interface. This is a real challenge when we know how difficult it is to differentiate PET from glass, as well as to detect paper.

TARGETED ISSUE

Waste recycling is an important part of our goods life cycle. The principle of recycling is to reuse the waste, but waste recycling facilities are facing a huge challenge: the disruptive wastes that are not well sorted and sorting errors represent additional management costs. The most known recyclable plastic type is Polyethylene Terephthalate (PET). Differentiating plastic types is a crucial sorting issue. One way to solve the sorting errors is going to the source of waste: people. By educating people as young as possible we can achieve fewer errors. Providing feedback to the recycling facilities managers can also help to decrease the error rate.

PROPOSED SOLUTION

In the recent years, there are several works on waste detection with deep learning [1][2]. In the waste and recycling industry, only a few companies [3] already use their own deep learning algorithms to sort materials more accurately and efficiently. None of them combines the gaming aspect with ML recognition to give feedback to the young children [4]. In fine, "LusTra" aims to develop an intelligent trash for educational purposes [5].

LusTrash deals with a recycle bin enhanced with a waste recognition system that educates children to properly recycle their waste [4]. It also provides statistics on the sorting quality in recycling bins thanks to an embedded system (Raspberry Pi and sensors). These statistics are provided to the facilities manager to improve the waste collection strategy. ML methods are used to train models [Bin18] [6] on the sensor data to recognize the types of waste and return the information to the child via a playful interface. We explore the performance of Convolutional Neural Networks (CNNs) inside the waste recognition system. In machine learning, CNNs are mostly specialized in image recognition. We started the project from scratch. We gathered our own dataset by setting up a trash can which contained an embedded video and lighting system. The camera takes pictures of the garbage being thrown away and a ML model classifies the images. One of the challenges was to develop the best ML classifier model from the pictures and evaluate its performance. We used and compared seven types of CNN algorithms. Moreover, "LusTra" is the unique system that combines the gamification aspect with the material recognition and predictive ML techniques to give feedback to young children.

LusTra [is] a motivating and playful sorting system, to educate the young public to the right gestures

RELEVANT INNOVATION

LusTra is the unique system that combines the gamification aspect with the material recognition and predictive learning techniques to give feedback to young children. Thus, LusTra aims to develop for educational purposes a mobile smart recycling prototype that can be deployed in different cultural events and awareness campaigns. The 4 labelled smart garbage cans integrating sensors and ML algorithms will allow the recognition of discarded materials, and the introduction of a feedback incentive interface (game) to sort garbage. For this purpose, a gaming interface prototype has already been developed. Among all the considered recycling proposals none of them combines the gamification aspect with the material recognition and predictive learning techniques to give incentive feedback to young children.

Moreover, LusTra also provides the manager with remote feedback about the sorting quality in recycling bins.

PROJECT OUTCOMES & RESULTS

Our results show that CNNs have difficulties distinguishing between PET and glass bottles on a classification "PET versus Other (non-PET)". It suggests that CNNs are strong to classify different shapes but weak when shapes are similar. It led us to try a classification of "Bottles versus Other (non-Bottle)" which performed better than "PET versus Other".

The gaming interface prototype has been developed as a wheel of fortune that 1) teaches children to correctly sort the different materials and 2) motivates correct behaviors with an incentive rewarding strategy.

CONCLUSION

The solution to use ML image recognition to classify "PET versus Other (non-PET)" recycling categories guarantees a trash can content with an approximate 10% error. A sorting system can use this solution in combination with other existing material identification techniques [7]. Our solution of a distributed Internet of Things (IoT) system takes advantage of a continuous improvement cycle.

PERSPECTIVES & NEEDS

We envision different tasks:

1) Applying the ML recognition methods on other materials as we mainly focused on PET.

2) For this purpose, we need the prior selection of sensors according to the materials.

3) Testing the playful interface in order to improve it as a final user application beyond the prototype.

4) Integrating the interface with the waste recognition system.

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