

# **Improving Reusability of Electronic Components**

**A PROJECT REPORT**

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*in partial fulfillment for the award of the degree of*

**BACHELOR OF TECHNOLOGY**

**IN**

**COMPUTER SCIENCE AND TECHNOLOGY(DevOps)**

**At**



**PRESIDENCY UNIVERSITY BENGALURU**

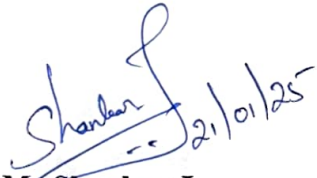
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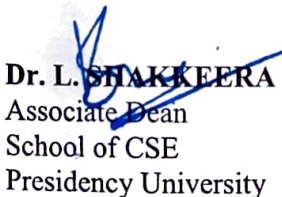
This is to certify that the Project report “**Improving Reusability of Electronic Components**” being submitted by DIBBAGALLA JOY, MORUBAGAL SIVANANDA GARI YESHWANTH, KOLLI SNEHITH REDDY, ARAVA VIGNESH RAJU, KALLIMEKALA BHARGAV TEJA bearing roll numbers 20211CDV0066, 20211CDV0039, 20211CDV0006, 20211CDV0067 in partial fulfillment of the requirement for the award of the degree of Bachelor of Technology in Computer Science and Technology(DevOps) is a bonafide work carried out under my supervision.



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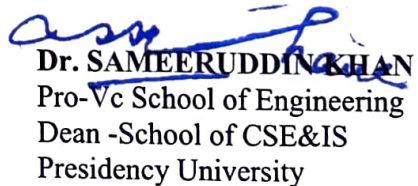
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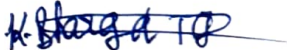
We hereby declare that the work, which is being presented in the project report entitled **Improving Reusability of Electronic Components** in partial fulfillment for the award of Degree of **Bachelor of Technology in Computer Science and Technology(DevOps)**, is a record of our own investigations carried under the guidance of **Mr.Shankar J, Asst.Prof(CSE), School of Computer Science and Engineering, Presidency University, Bengaluru.**

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## ABSTRACT

The project "Improving Reusability of Electronic Components" addresses one of the global most crucial and growing challenges: electronic waste, commonly called e-waste. This problem has become an increasingly urgent issue owing to the acceleration of technological advance and the dissemination of electronic equipment throughout all reaches of the earth. While these devices have had the transformative effect of the everyday lives of numerous persons, their sheer number and the frequency of replacement has become a significant environmental concern. There's even an immense amount of resource that get lost from these electronics. The project thus emphasizes that the sustainability concept will gain more importance once electronic parts are handled with their life cycle being considered in particular the disposal and recycling processes. This project is founded on research and development to utilize the disruptive power of artificial intelligence and machine learning to develop an innovative and resilient system.

The system is supposed to assess, classify and improve the reusability of electronics that mainly include laptops (one of the most utilitarian yet most discarded commodities in the world). Use advanced levels of methodologies for AI and ML to reinvent the manner of handling electronic components in this venture-for building a clean and green surrounding.

Within this system lie roots that classify electric components based upon condition, then allow for explicit decision-making under this framework-the model classifying based on only two conditions in determining whether component is fully functionally or else not. This binary classification system is instrumental in determining the next steps for each component, whether it involves reuse, repair, recycling, or disposal. For components classified as fully functional, the system further provides actionable insights, such as potential fixes or upgrades, which can extend the lifespan of the device. This approach not only maximizes the utility of the electronic components but also reduces the frequency of premature disposal.

The system takes it a step further by identifying whether the non-functional components can be recycled or disposed of as e-waste. It identifies the recyclable materials from each non-functional component based on their specific condition to ensure that there is an efficient processing of such materials with minimum environmental footprint of discarded electronics. The actionable insights that the system gives out are aligned with the distinct nature of each component, thereby making sure that all possible value recovery and waste reduction are accomplished.

The project, therefore, underscores the significance of automated classification in addressing the e-waste problem. Automated evaluation and classification of electronic components, the system will increase efficiency but reduce the margin for human error. The automation is important to control the ever-increasing amount of e-waste that is produced around the world and ensure each material is processed in as environmentally friendly a way as possible. AI and ML initiatives allow the system to learn and refine its classification accuracy and decision-making over time, rendering it an ever-evolving solution to e-waste.

By minimizing e-waste and its environmental burden, the overall aim of the project is to promote sustainability within the electronics sector. It will do this by allowing for re-use and repair of electronic components to prolong the components life and by ever increasing recycling/disposing of components that there are no better uses for, thereby creating a circular economy of electronics.

## ACKNOWLEDGEMENT

First of all, we indebted to the **GOD ALMIGHTY** for giving me an opportunity to excel in our efforts to complete this project on time.

We express our sincere thanks to our respected dean **Dr. Md. Sameeruddin Khan, Pro-VC**, School of Engineering and Dean, School of Computer Science and Engineering & Information Science, Presidency University for getting us permission to undergo the project.

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We are greatly indebted to our guide **Mr. Shankar J, Asst.Prof(CSE)** and Reviewer **Mr. Ramamurthy Ketha, Asst.Prof(CSE)**, School of Computer Science and Engineering, Presidency University for his inspirational guidance, and valuable suggestions and for providing us a chance to express our technical capabilities in every respect for the completion of the project work.

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We thank our family and friends for the strong support and inspiration they have provided us in bringing out this project.

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## CHAPTER-1

### INTRODUCTION

Electronic waste is one of the deadliest environmental threats to an advanced world. In large part because of rapid technological advancement and resultant obsolescence of electronic devices, vast heaps of electronic materials are getting thrown away or consigned into oceans and ground waste. Additionally, the wastage of the depleted natural resource besides environmental deterioration have been aggregated through unhygienic disposal and as a consequence from e-wastes, poisoning seep through toxic materials soil and water systems. Hence, finding a solution for this dual problem of waste management and resource conservation requires innovative approaches that combine technology, sustainability, and public engagement.



**Fig 1 – Global E-waste Management**

Our project using machine learning and web-based technologies to improve the responsible management of e-waste, "Improving Reusability of Electronic Components," is an innovative solution. In other words, it means making the usability of people's electronic components easy to check so that insights may be drawn from it, thereby encouraging the repair, reuse, or proper disposal of components. This focus on sustainability and user empowerment can bridge the gap between ecological responsibility and technological advancement.

The project is centered on a web application that easily allows users to upload images of electronic components. At the center of this system is a deep learning classification model, which was carefully trained on over 21,000 images of electronic components. This model is developed using TensorFlow and is expected to recognize a wide range of electronics, from laptops and smartphones to circuit boards and other typically discarded devices. There are three major conditions for determining the reusability of the component on which classification is based:

**1. Partially Functioning:** Pieces found in this group can be repaired or repurposed. The application provides recommendations for repair methods or alternative usages that extend the life cycle of the component.

**2. Fully Functional:** These parts are considered good enough for direct reuse or donation. The system encourages users to donate fully functional items to avoid waste and fulfill community needs.

**3. Non-Functional (Disposable):** For parts that cannot be repaired or reused, the application emphasizes proper recycling and guidelines for environmentally friendly disposal to minimize environmental impact.

A well-integrated deep learning model using Streamlit-based web application provides the ease of accessibility and usage for the user. The user is given immediate feedback on their uploaded images with step-by-step recommendations for further action. The use of a highly accurate model that has been trained on an extremely diverse dataset makes it possible to provide accurate classification results, aiding the user in making decisions for their e-waste. This project can help considerably reduce the amount of environmental damage caused by e-waste by simplifying the assessment process and equipping people with knowledge. It fosters a culture of sustainability through promoting repair and reuse rather than disposal and creating awareness about the ecological implications of electronic waste. Furthermore, the solution is scalable in such a way that it could be adapted to different geographical and demographic contexts thus achieving global reach and impact.

In summary, "Improving Reusability of Electronic Components" is the pioneering effort that addresses the serious issue of e-waste. This project embodies a union between advanced machine learning techniques and user-centric design to provide practical and impactful solutions melding technological innovation with ecological stewardship. The project calls for responsible consumer behavior to contribute to building a green and sustainable future.

## **1.1 Electric Component Reusability**

### **1.1.1 Overview:**

This project brings into focus an important issue in the modern world of electronic waste (e-waste), using artificial intelligence to evaluate and classify the reusability of electronic components. Combining a powerful machine-learning model with an easy-to-use application interface, the system makes possible a very practical approach to sustainable e-waste management. <sup>[1]</sup>

### **1.1.2 Key Concepts:**

#### **1. Image-Based Classification:**

This feature is the core of the system, enabling users to classify electronic components using images.

##### **How It Works:**

The user submits an image of an electronic component, such as a laptop, smartphone, or circuit board, via the web application. A trained convolutional neural network (CNN) then analyzes the uploaded image to categorize the component into one of the established categories. The model provides the predicted type of component along with a confidence score that reflects the accuracy of its prediction. <sup>[2]</sup>

**Advantages:**

Simplifies component identification for users without technical knowledge.

Copes with diverse component appearances, including worn or partially damaged items.

**2. Reusability Assessment:**

The system assesses the condition of the identified component and classifies it into one of three reusability conditions.

**Categories:**

➤ **Fully Functioning:**

The component is in working condition and ready for immediate reuse or resale.

➤ **Partially Functioning:**

The component has minor issues but contains functional parts that can be repaired or repurposed.

➤ **Non-Functioning (Disposable):**

The component is beyond repair and must be disposed of responsibly through recycling.

**How It Adds Value:**

Provides actionable insights into the condition of the component.

Encourages users to repair and reuse products before considering disposal, meeting sustainability objectives.

**3. Recommendations Module:**

Post-reusability analysis, the system gives specific recommendations based on the component's state.

**Recommendations Include:**

➤ **Repair Strategies:**

For partially working components, the system recommends repairs (e.g., screen replacements, battery replacement, or minor hardware repairs).

➤ **Reuse Options:**

For fully working components, the system suggests resale, donation, or repurposing options (e.g., old laptops can be used as educational tools or media centers).

➤ **Recycling Guidance:**

For broken components, the system suggests certified e-waste recycling centers or programs.

➤ **Unique Features:**

Provides specific recommendations for the type of component.

Arms users with information to make environmentally friendly choices.

**4. User-Friendly Interface:**

The project is designed with a Streamlit-based web application, making it accessible and easy to use for all users, regardless of their technical skills.

**Interface Features:**

➤ **Image Uploader:**

- Enables users to upload images in standard formats like JPG, PNG, or JPEG.

Displays a preview of the uploaded image before processing.

➤ **Real-Time Results:**

- Shows the predicted component type and confidence score immediately after image processing.
- **Interactive Design:**
  - Provides easy navigation with clear headings to upload, view results, and recommendations.
- **Benefits to Users:**
  - Fast and smooth interaction, even for first-time users
  - Less technical jargon, so more people can use the system

## **5. Immediate Feedback and Information:**

The system shows instant results to the user, minimizing wait time and improving usability.

### **Feedback Provided:**

- **Component Identification:** The user gets clear information about the predicted electronic component
- **Confidence Levels:** Shows how confident the system is in its prediction to help users trust the results
- **Next Steps:** Clear guidance on what actions to take, whether re-use, repair, or recycling

### **How It Provides Engagement:**

- Lets users know what their contributions are to sustainable efforts.
- Encourages repeated use of the platform because of its speed and reliability.

## **6. Scalable and Modular Design:**

The system is designed to scale up and adapt as needs change.

### **Characteristics of Scalability:**

- **Extensible Dataset:** Expand the dataset with new categories of electronic components to enhance classification coverage.
- **Integration Options:** The system can link with external APIs for recycling center locations or repair service directories
- **Cloud Deployment:** Future deployment on cloud platforms ensures accessibility for users around the world.

### **Why This Matters:**

- Keeps the system relevant as technology and electronic devices evolve.
- Covers a broad spectrum of applications, catering to everyone from individual users to large organizations.

## **7. Sustainability-Centered Strategy:**

This feature is integral to the project's goal of promoting environmental responsibility.

### **How It Works:**

- The system emphasizes repairing and reusing components to extend their lifecycle.
- For non-functioning items, it directs users to certified recycling programs, reducing the risk of improper disposal.
- Generates educational content about sustainable practices, such as upcycling or eco-friendly disposal.

**Impact:**

- Reduces the environmental footprint of electronic waste.
- Encourages users to adopt sustainable habits in their daily lives.

**8. Optional Features for Future Enhancements:**

These features can be integrated into the system later:

- **Save Results:** Allow users to download or save reusability assessments for reference.
- **Mobile Compatibility:** Develop a mobile-friendly version or app for increased accessibility.
- **Gamification:** Introduce rewards or badges for users who frequently recycle or repair components.

**1.1.3 Preprocessing Steps:**

**Fig 2 – Dataset Preprocessing**

Preprocessing prepares the data set for maximum model performance—ensuring consistent and quality data. Below is the summarized code:

**1. Dataset Organization:**

- Divide data into training, validation, and testing subsets, with categories organized for efficient loading.

**2. Image Resizing:**

- Resize all images to a fixed size, like 180x180 pixels, for better uniformity.

**3. Normalization:**

- Scale pixel values to a range of 0–1 to improve model convergence.

**4. Data Augmentation:**

- Apply techniques such as flipping, rotation, zooming, and brightness adjustments to increase dataset diversity and reduce overfitting.

**5. Dataset Splitting:**

- Ensure proper splitting in training, validation, and test subsets, normally an 80-10-10 ratio.

**6. Label Encoding:**

- Convert categorical labels (e.g., Laptop, Smartphone) into numerical representations for
-



the model.

#### **7. Batch Loading:**

- Load data in small batches (e.g., 32 images per batch) for memory efficiency and faster processing.

#### **8. Shuffling:**

- Shuffle the training data to avoid model bias due to sequential patterns.

#### **9. Validation and Test Preparation:**

- Use separate validation and test datasets without shuffling for unbiased evaluation.

#### **10. Data Inspection:**

- Plot a sample of images and check class distribution to ensure data integrity.

These preprocessing steps ensure the dataset is clean, consistent, and well-prepared for training a high-performance model.

### **1.1.4 Challenges:**

#### **1. Imbalanced Dataset:**

- **Issue:** Some categories of electronic components had significantly fewer images compared to others. Classes such as "Cracked Screen Smartphone" may have been less represented, potentially resulting in biased predictions.
- **Impact:** While the model might perform well for the classes that are overrepresented, it could struggle with those that are underrepresented, which would decrease both accuracy and fairness overall.
- **Solution:** To tackle this imbalance, methods like data augmentation and oversampling were used.

#### **2. Composite Component Variations:**

- **Issue:** Variations in lighting, angles, and component conditions (e.g., damaged, old, or partially visible components) made accurate classification difficult.
- **Impact:** Reduced prediction accuracy for images that deviated significantly from the training data.
- **Solution:** Data augmentation and increasing dataset diversity with more representative samples were implemented to improve model robustness.
- 

#### **3. Real-Time Prediction Latency:**

- **Issue:** Real-time image uploads and predictions required the system to process data quickly, especially when handling large images or batches.
- **Impact:** Delays in predictions could affect the user experience, especially in interactive applications.
- **Solution:** Optimized the model size and used efficient preprocessing pipelines to reduce latency without compromising accuracy.

These challenges highlight the importance of data quality, model robustness, and system optimization in developing AI-powered solutions.

### **1.1.5 Applications:**

This project addresses a wide range of applications across various domains,

directed toward sustainability, optimization of resources, and e-waste management. The following represent the major applications:

### **1. E-Waste Management and Recycling:**

- **Application:** To enable proper classification and disposal of electronic waste.
- **Impact:**
  - Encourages responsible recycling of e-waste by pointing out those parts no longer in working order.
  - Reduces pollution by directing users on where functional waste will be accepted for recycling.

### **2. Circular Economy Support:**

- **Application:** Contribution towards preventing premature demise of electronic devices.
- **Impact:** stimulates recycling through the eyeing of committed components provides repair remedies for partly malfunctioning others to minimize waste production.

### **3. Consumer Education and Awareness:**

- **Application:** enlightens the consumers with the sustainability of electronic devices.
- **Impact:**
  - Raises awareness of repair, reuse, and recycle options.
  - Facilitates well-informed decisions from users, hence lessening e-waste generation.

### **4. Repair and Refurbishment Services:**

- **Application:** Helps repair shops and refurbishment centers by pointing out the reusable parts from discarded electronic devices.
  - **Impact:**
    - Promotes optimum retrieval of valuable components from discarded electronics.
    - Builds trust with subsequent sellers by providing reliable evaluations of product functionality.
5. E-commerce and Resale Platforms: Application: Allows to enhance quality of second-hand electronics listed with the platforms.

## **1.2 Training CNN Model:**

### **1.2.1 Overview:**

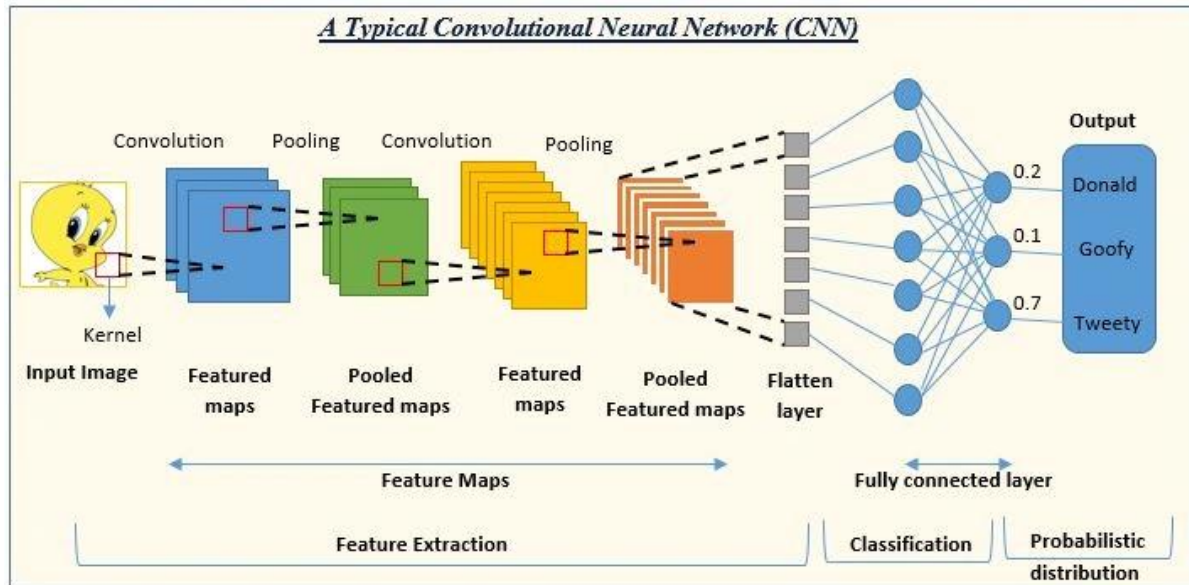
The training of deep learning models under the project "Improving Reusability of Electronic Components" consisted of a set of well-planned steps aimed at maximizing accuracy and robustness. Below is a detailed description of the model training process.

### **1.2.2 Key Steps:**

#### **1. Model Architecture:**

- A CNN was used for such tasks since they were highly efficient in image classification.
- Key Layers:
  - Rescaling Layer: Normalizes pixel values to the range [0, 1].
  - Convolutional Layers: Extract spatial features using filters.
  - MaxPooling Layers: Reduce dimensionality while preserving essential features.
  - Dropout Layers: Help prevent overfitting by randomly disabling neurons during training.

- Dense Layers: Map the extracted features to output classes (14 component categories).



**Fig 3 – CNN Architecture**

## 2. Training Dataset:

- Data Source: A dataset containing over 21,000 labeled images across 14 categories of electronic components.
- Data Split:
- Training Set: 80% of the data.
- Validation Set: 10% of the data.
- Test Set: 10% of the data.

## 3. Preprocessing:

- Prior to inputting the data into the model, the following preprocessing steps were taken:
  - Resizing images to a standard size (180x180 pixels).
  - Normalizing pixel values to a range of 0–1.
  - Augmenting the dataset with random flips, rotations, and zooms to enhance generalization.

## 4. Training Configuration:

- Loss Function:
  - Sparse Categorical Crossentropy, suitable for multi-class classification.
- Optimizer:
  - Adam optimizer, selected for its adaptive learning rates and efficient convergence.
- Metrics:
  - Accuracy, used to track performance during training.

## 5. Training Process:

- Batch Size: 32 images per batch to optimize memory usage.
- Epochs: The model was trained for 50 epochs, striking a balance between convergence

and computational efficiency.

- Validation: An independent testing dataset was taken in conjunction with the validation dataset to track performance and reduce the overfitting effect.

## 6. Evaluation:

- After training ended, we did a test set assessment to evaluate general performance for unseen data. The metrics computed for each category include accuracy, precision, recall, and the F1-score.

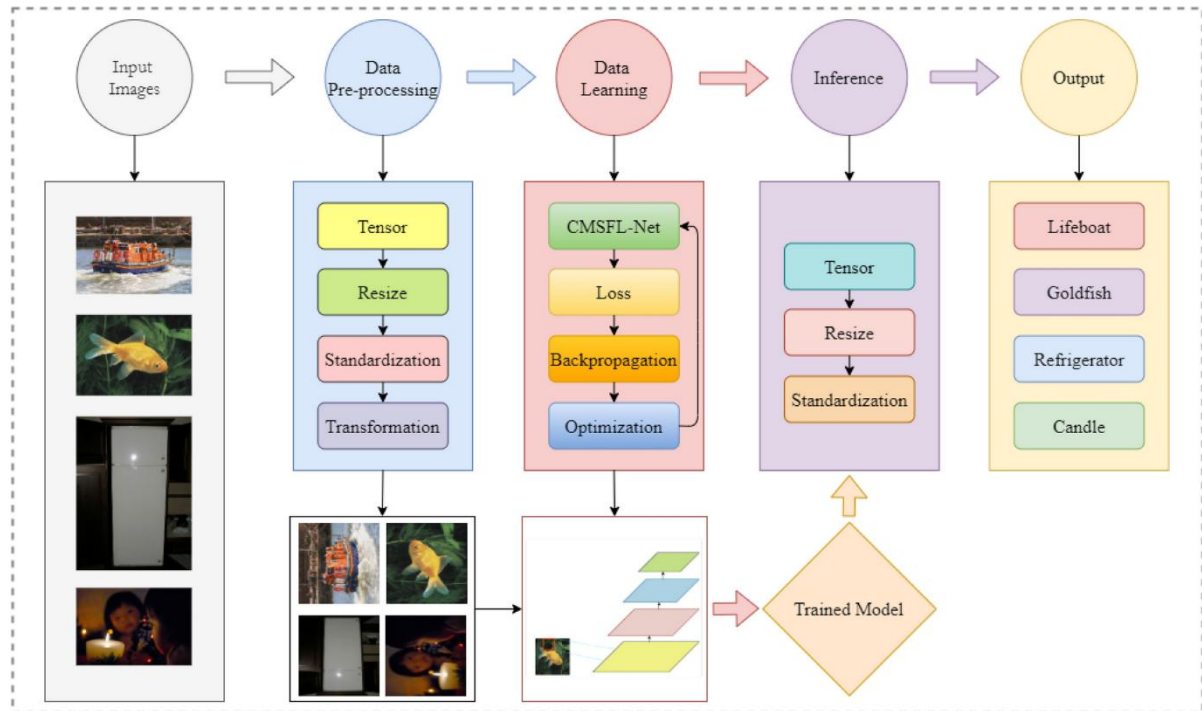


Fig 4 – Image Dataset Based Classification

### 1.2.3 Technology Integration:

#### 1. Programming Languages:

- Python: Model development, preprocessing, and application logic

#### 2. Machine Learning Frameworks:

- TensorFlow and Keras: Deep learning model creation and training.

#### 3. Web Development:

- Streamlit: To create a lightweight, interactive user interface.

#### 4. Data Handling:

- NumPy and Pandas: Preprocessing and management of dataset structures.
- TensorFlow Image Dataset: Efficient loading and handling of image data.

#### 5. Visualization:

- Matplotlib: Plotting accuracy and loss during training.

#### 6. Deployment Platforms (optional):

- Local Deployment: Running Streamlit locally for small-scale use.
- Cloud Services: AWS, Google Cloud, or Heroku for large-scale deployment and accessibility.

#### 7. Optional Integration:

- External APIs for recycling center recommendations.

## **CHAPTER-2**

### **LITERATURE SURVEY**

#### **2.1 Overview:**

The project literature review addresses the general state of electronic waste management, the functions of machine learning in image classification, as well as the strategy for promoting circular economy. As this review is comprehensive, it brings to light the concerns, issues, and gaps that this project intends to fill.

#### **2.2 Electronic Waste Crisis:**

##### **2.2.1 Statistics on E-Waste Generation and its Effects Globally**

- As per Global E-Waste Monitor 2020 the report enunciated that in 2019 it was estimated that e-waste generation was about 53.6 million metric tons, recycling through proper channels accounted for only 17.4%. Despite the fact that e-waste hides valuable materials such as gold, silver, and copper, improper recycling may give rise to environmental and health problems. Activities carried out by the United Nations Environment Programme show the key role responsible management and recycling of e-waste can play in sustainable development. <sup>[3]</sup>

##### **2.2.2 Importance of Reusability**

- Prolonging the lifespan of electronic components helps minimize waste and conserve important resources. Research, including findings from Forti et al. (2020), indicates that reusing functional or repairable components is more efficient in terms of resource use compared to recycling. Additionally, studies highlight the necessity for automated tools that can evaluate reusability and suggest suitable actions.

#### **2.3 Role of Machine Learning in Image Classification**

##### **2.3.1 Advancements relating to Deep Learning**

- It won't be fake to say that the Convolutional Neural Network approach towards deep learning has re-shaped the way we classify images.
- In-depth analysis models' performances on large scale data sets was gladly accepted by AlexNet, ResNet and VGGNet where assumption of accuracy within intricate situations was made.
- CNNs are particularly robust spatial feature extractors from images, as demonstrated in the works of LeCun et al. (2015).

##### **2.3.2 Application in E-waste:**

- Another study classified e waste into different categories using machine learning models – laptops, smartphones, and even circuit boards.
- In this sense, Jain & Gupta (2021) was able to classify e-waste with a CNN, and then classify the recyclability of this e-waste as well, achieving high accuracy.

Some problems that were noted include computational needs, dataset diversity, and a large number of classes.

### **2.3.3 Data Augmentation:**

- Techniques like resizing, normalizing, and augmenting images (flipping, rotating and other methods) can notice the improvement in robustness of the model or network during the training phase.
- There's a common consensus that model training would be possible only when a sufficiently large and balanced dataset is available.

## **2.4 Reusability Evaluation in the Contexts of Circular Economy:**

### **2.4.1 Keys to Success for Circular Economy:**

- A circular economy emphasizes on reduction, reuse, and recycling of resources (Johnson, 2013), and it has been described by the European Commission as an important approach to cope with sustainability challenges (2019).
- The broad principle of circular economy is embodied in reusability assessments by seeking to prolong the use of components and help the environment.

### **2.4.2 Methods for Reusability Assessment of Electronics:**

- In their work, Widmer et al. (2005) also consider that it is important to be able to assess the value of the lifecycle of means of electronic components and propose a usable framework for measuring it.
- Such practical frameworks do integrate the condition assessment with other basic preliminaries such as repair strategies or even recycling recommendations.

### **2.4.3 Areas for further study:**

- There are also limited tools available to the public to assess the ecommerce reusability of electronics directed toward consumers.
- There is a need for systems that merge the amount of automatic classification with the amount of practical insight, thus facilitating user experience and the entire idea or strategy behind the technology.

## **2.5 Emerging trends of the future:**

### **2.5.1 AI's Role in Environmental Sustainability**

- More and more AI-based tools are being implemented in the enhancements of recycling operations, supervision of waste streams, and evaluation of potential for resource recovery.
- Kang & Schoenung (2005) research notes on the contribution over AI in developing e-waste management procedures.

### **2.5.2 IoT Integration And Efficient Management Practices In Waste:**

- With the integration of IoT and AI, there is a capability of tracking and categorizing e.waste as it is being produced, in real-time.
- Some researchers have proposed use of IoT sensors along with machine learning models for accurate identification of the components.



**Fig 5 – AI in Environmental Health**

### **2.5.3 Broader Strategies Engagement Calculating Polluters and Raising Awareness Amongst Stakeholders:**

- Extended Producer Responsibility (EPR) policies make it compulsory for companies to devise ways of recycling their products when they reach the end of their lives.
- Public awareness campaigns can encourage the use of such tools as the one created in this case project. <sup>[4]</sup>

## **2.6 Current Project and Its Contributions:**

### **2.6.1 Filling Research Gaps:**

Approaches actionable reusability recommendations by bridging the space between user and automation through a CNN based classification which is active reusability.

### **2.6.2 Implementation:**

- Again, the use of a Streamlit interface allows the average user to use advanced Artificial Intelligence tools without needing much guidance to do so.
- Helps to promote sustainable practices, by offering repair, reuse, and recycle options.

### **2.6.3 Expected Scope:**

- The project paves a path for integration of new features like links to recycling programs and repair guides.
- Increasing the diversity of dataset and enhancing the model allows to further extend its value



## CHAPTER-3

### RESEARCH GAPS OF EXISTING METHODS

The review of the existing approaches to the management of electronic waste (e-waste) and the management of electronic components entails a number of problems and areas for improvement. The project “Improving Reusability of Electronic Components” seeks to fill in those gaps.

#### 3.1 Insufficient Reusability Evaluation:

- **Gap:** The majority of the solutions currently available place an emphasis on recycling or on bounding e-waste into broad categories but do not go the extra mile of undertaking reusability evaluation (for example determining which components that can be repaired or reused).
- **Impact:** Working components are often considered as waste or are disposed of as trash which is in most cases unneeded.
- **Opportunity:** Make possible automated techniques for functional parts evaluation based on their characteristics: functional – fully functional (for use), partially functional (for repair), and non-functional (for parts);

#### 3.2 Not Profound Utilization of Modern Machine Learning Models:

- **Gap:** Some systems utilize elementary machine learning algorithms in the classification of e-wastes but such do not incorporate the more advanced and precise algorithms that modern vicissitudes of deep learning such as CNN’s provide.
- **Impact:** These systems have been proven to be less reliable due to their lack of accuracy especially for fully damaged or complex components.
- **Opportunity:** Leverage best deep learning technologies in the improvement of classification accuracy and different designs of a given component.

#### 3.3 Lack of Variety Across the Dataset:

- **Gap:** Currently existing datasets for e-waste classification are too generic and do not consider other necessary components such as component types, condition factors, and environmental factors including lighting and background noise.
- **Impact:** Due to the datasets that are available, the models that are created using the information are not generalizable, thus providing suppressed results in real life.
- **Opportunity:** Construct or improve the datasets that are available by adding more images of diverse conditions, angles, and lighting settings.



**Fig 6 – Multi Labelled Dataset**



### **3.4 Insufficient User Friendliness and Accessibility for End Users:**

- **Gap:** Several e-waste tools are not user friendly, and hence, e-waste management software requires highly technical individuals to be able to operate them or has a very complicated user interface.
- **Impact:** The software has a very low to non-existent adoption rate, especially among people who are not technical, for instance, everyday consumers, small businesses and community entities.
- **Opportunity:** An easy to use application based on the web can be designed, for example, Streamlit, which allows users to upload images and get the desired results without possessing technical knowledge.

### **3.5 Absence of integration with sustainable practices:**

- **Gap:** most current technologies ignore the reuse and repair policies of a circular system economy including devices when the initial scope should have been promoting for disposal
- **Impact:** Confiscated chances of extending the duration of use of electronic components and minimizing the adverse effect of e-waste.
- **Opportunity:** Add recommendations for repair, reuse, and recycling with the goal of influencing better choices in decision-making.

### **3.6 Absence of solutions that are both real time and able to be scaled up:**

- **Gap:** There are some existing approaches use but they are few that enables users to post an image, and the system automatically processes it in real-time. When it comes to large amounts of data and mass usage, many systems do not scale well
- **Impact:** Feasible applicability in real-life cases whereby speed as well as reliability is needed.
- **Opportunity:** Efficient preprocessing pipelines and scalable deployment options, such as cloud platforms, that allow for widespread use while providing real-time predictions.

### **3.7 Insufficient Education and Insight concerning Integration with the Recycling System:**

- **Gap:** Existing platforms are unable to reach out to consumer and inform them about recycling or repair facilities available in their locality.
- **Impact:** An element that still remain in proper working condition can be disposed of incorrectly as a result of the lack of directions or recycling infrastructure.
- **Opportunity:** APIs and external databases could also be used to inform about the location of the nearest center for recycling and repair of the device or a donation site.

### **3.8 Components with Multiple Robustness's Cannot Be Catered To:**

- **Gap:** Existing models usually do not incorporate components that have mixed conditions such as partially damaged but repairable components.
- **Impact:** Classifications that are made in a bid to make quick decisions can be over generalized resulting in illegitimate recommendations that do not correspond to the

options provided.

- **Opportunity:** Because it is quite specific, multi-condition evaluation logic should be used as a strategy to be able to provide both effective and accurate recommendations.

### **3.9 Direct Your Attention Toward Recycling Instead of Repairs or Reuse:**

- **Gaps:** The majority of all designs tend to focus on the act of recycling while the options of repair or reuse which tend to be more resource efficient are completely neglected
- **Impact:** There is an opportunity where parts, components and other valuable assets may be recycled even when they can be reused.
- **Opportunity:** There is a need to increase awareness of repair and reuse opportunities along the waste hierarchy (Waste management principles; “Reduce, Reuse and Recycle”).

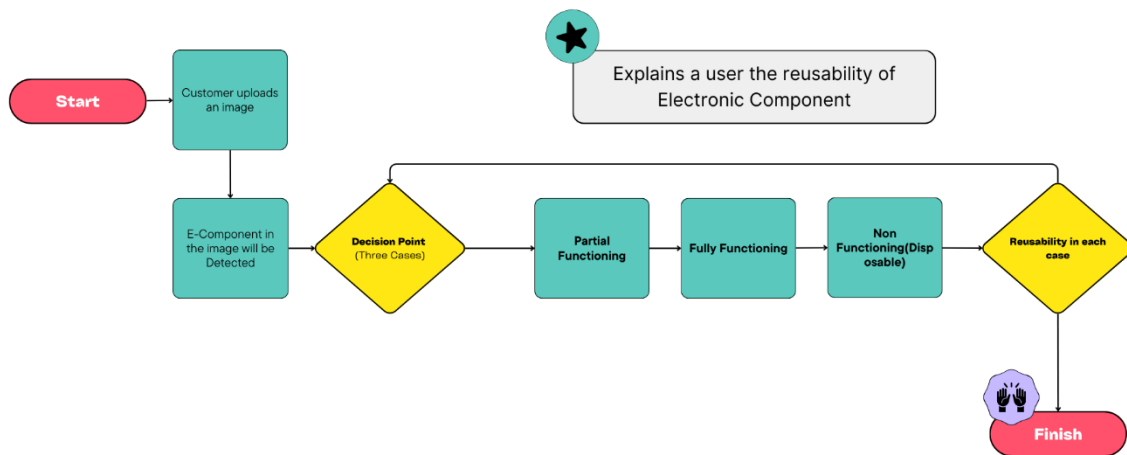
### **3.10 Inadequate Policy Coordination and Data Tracking:**

- **Gap:** The current mechanical approaches fall short in integrating with certain policies like EPR mechanisms. Also they are lacking tools for environmental impact assessment.
- **Impact:** Lost opportunity to affect policy or provide useful insights for active sustainability interventions.
- **Opportunity:** Creating or designing systems that consider integration with policies and provide data on the management of e-waste.

## CHAPTER-4

### PROPOSED METHODOLOGY

The methodology is developed for the project "Improving Reusability of Electronic Components," which will provide a comprehensive solution for the classification of electronic components and the estimation of their reusability. The project aims to combine the modes of machine learning and image processing and the design of friendly applications to create an environment suited to the demands of this project.



**Fig 7 – Architecture Diagram**

#### 4.1 Problem Statement:

- Create an automated system that can identify electronic components from images and evaluate their reusability based on three conditions:
  - Fully Functioning
  - Partially Functioning
  - Non-Functioning
- Offer practical recommendations for repair, reuse, or recycling to support sustainability.

#### 4.2 Data Collection and Preparation:

##### 4.2.1 Dataset collection:

More than 21,000 images showing 14 kinds of electronic components like smartphones, laptops, circuit boards, and many others are included in the dataset. It was fetched from the online repositories, manual collection, and public dataset.

##### 4.2.2 Preprocessing:

All images resized uniformly to a dimension (180x180 pixels, for example).

- **Normalizing:** Scaling the pixel values between 0-1 increases the ease of training the

model.

- **Augmentation:** Random flips, rotations, zooms, color brightness adjustments to diversify the dataset and create a more robust system.
- Dataset segregations are train (80%), validation (10%), and test set (10%).

### 4.3 Model Development:

#### 4.3.1 Model Architecture:

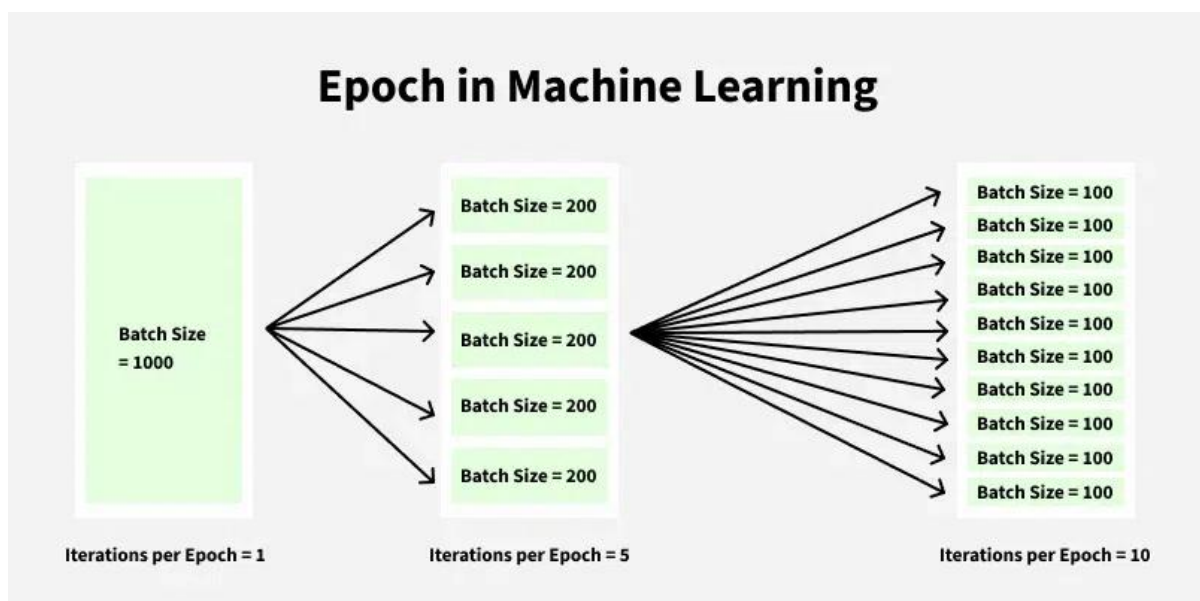
- The Convolutional Neural Network (CNN) has its valid performance in visual recognition tasks, hence being used for image classification. <sup>[7]</sup>
  - **Rescaling Layer:** Normalizes input pixel values.
  - **Convolutional Layers:** Extracts spatial features from images.
  - **Pooling Layers:** Reduces dimensionality while preserving essential features.
  - **Dropout Layer:** Prevents overfitting.
  - **Dense Layers:** Maps extracted features to desired output classes.

#### 4.3.2 Model Configuration:

- **Loss Function:** Sparse Categorical Crossentropy- Multi-class classification.
- **Optimizer:** Adam optimizers to converge and learn.
- **Evaluation Metric:** Accuracy for observing model performance during training.

#### 4.3.3 Training:

- **Batch Size:** 32 images per batch enough for memory optimization.
- **Epochs:** 10-15 epochs for optimal convergence.
- **Validation:** Performance tracked on the validation dataset, put in place to avoid overfitting.



**Fig 8 – Epochs Training**

## **4.4 Reusability Evaluation:**

### **4.4.1 Component Categorization:**

- The model gives a confidence score to predict the component type, for example, Smartphone, Laptop.

### **4.4.2 Condition Evaluation**

- Maps the predicted component to one of three conditions based on predefined logic:
  - **Fully Functioning:** No visible defects; ready for reuse.
  - **Partially Functioning:** Minor issues that can be repaired.
  - **Non-Functioning:** Severe damage; suitable for recycling.

### **4.4.3 Actionable Insights:**

- Gives personalized recommendations:
  - Repair suggestions for partially functioning components.
  - Reuse or donation options for fully functioning components.
  - Recycling guidance for nonfunctioning parts

## **4.5 System Development:**

### **4.5.1 Web Application:**

- Technology/ Framework used: Streamlit for the development of interactive and user-friendly Web Interface
- Features:
  - Facility to upload images
  - Display of real-time predictions of the type and condition of the component
  - Confidence scores along with recommendations

### **4.5.2 Backend Integration:**

- The trained model is integrated into the application for seamless prediction and assessment.

### **4.5.3 Optional Features:**

- Saving results for future reference.
- Integration with external APIs to suggest nearby recycling centers or repair services.

## **4.6 Deployment:**

### **4.6.1 Local Deployment:**

- The application undergoes local testing to verify its functionality and accuracy.

### **4.6.2 Cloud Deployment:**

- Deploy the application on platforms such as AWS, Google Cloud, or Heroku to ensure global accessibility.

## **4.7 Evaluation:**

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- Model Evaluation: Accuracy of the model and F1 score evaluated on the unseen test dataset.
- Testing the application: Usability and response time will be tested for real-world scenarios.
- Get user feedback: Collect feedback from early users to refine recommendations, with an intention to make the user interface even better.

#### **4.8. Iterative Refinement:**

- Add more diverse images and categories.
- Experiment with advanced architectures such as ResNet or MobileNet to get better accuracy.
- Add additional features like prediction of repair cost or resale value estimation.

## CHAPTER-5

### OBJECTIVES

#### 5.1 Electronic Components Efficient Identification

- **Goal:** Using a machine learning model, identify electronic components in a user provided image accurately.
- **Consequence:** Allow smartphone, laptop, circuit board and more users to easily and accurately identify devices without requiring person's skill set.

#### 5.2 Reusability Evaluation and Classification

- **Goal:** Once the component is identified, evaluate its quality and group it into one of these three types: Fully Functioning, Partially Working and Non-Working (Throw away)
- **Impact:** Reuse as well as repair is encouraged, hence leading to less of valuable materials' scampering which is a bad concern for the environment.

#### 5.3 Encourage Going Green

- **Objective:** Based on a component's condition recommend to either fix it, reuse it or recycle it.
- **Impact:** Assist the environment by increasing the duration which an electronic device can be used for and less the e-waste produced.

#### 5.4 User Friendly Interface to Cater to All Needs

- **Objective:** Using Streamlit, design an interactive and easy to use web application that provides users with real time results. <sup>[8]</sup>
- **Impact:** Make sure the system can be used through the consumers, repair businesses and organizations without advanced skills and experience.

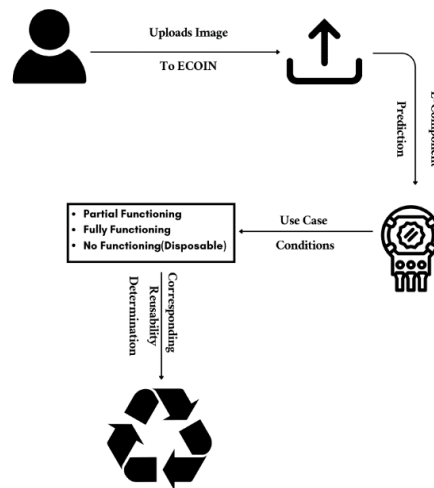
#### 5.5 Foster Circular Economy Approaches

- **Objective:** Support resource circular economy thinking and practice with an emphasis on resource optimization.
- **Impact:** Minimize the environmental impact of electronic waste and contribute to worldwide sustainability initiatives.

## CHAPTER-6

### SYSTEM DESIGN & IMPLEMENTATION

The "Improving Reusability of Electronic Components" system is built to classify electronic components based on their visual features and evaluate the reusability. It integrates an advanced image preprocessing, a deep learning model, and an interactive user interface in order to guarantee smooth user interaction as well as the accuracy of the predictions.



**Fig 9 – System Working**

## 6.1 Main Elements:

### 6.1.1 Image Acquisition:

- **Goal:** Enables users to upload images of electronic components using a web-based interface.
- **Explanation:**
  - Accepts common formats like JPEG or PNG to ensure compatibility.
  - Ensures proper resolution for accurate analysis.

### 6.1.2 Image Preprocessing:

- **Purpose:** Prepares images for analysis by enhancing key features.
- **Details:**
  - Resizes images to a uniform dimension (e.g., 180x180 pixels) to maintain consistency.
  - Normalizes pixel values to improve model performance.
  - Applies data augmentation techniques (e.g., flipping, rotation) to simulate diverse conditions and reduce overfitting.

### 6.1.3 Feature Extraction and Classification

- **Purpose:** Identifies visual features and classifies the component type.
- **Details:**
  - Utilizes a Convolutional Neural Network (CNN) to automatically extract features,



including spatial characteristics like shape and edges. It classifies the components into 14 predefined categories using a pre-trained model, such as ResNet or a custom TensorFlow model.

#### **6.1.4 Output Visualization:**

- Displays the processed results to the user.
- **Details:**
  - Displays the name of the component, type, and prediction confidence score.
  - Gives reusability assessments in terms of being fully functional, partially functional, or non-functional with actionable recommendations.

#### **6.1.5 Database Integration**

- **Purpose:** Stores image data, predictions, and metadata for tracking and analysis.
- **Details:**
  - Saves user-uploaded images, classification results, and timestamps for future reference.
  - Enables feedback collection for system improvements.

### **6.2 Implementation Plan:**

#### **Step 1: Dataset Collection and Preparation**

##### **Collect Dataset:**

Source images of electronic components under varying conditions (lighting, angles, and environments).

##### **Label Data:**

Annotate images with accurate component names and types.

##### **Data Augmentation:**

Enhance dataset variability using transformations such as flipping, rotation, zooming, and scaling.



**Fig 10 – Data Augmentation**

## Step 2: Model Training

### Model Selection:

- Choose a strong deep learning architecture, such as ResNet, VGG, or MobileNet, for classification.

### Training:

- Train the model on the annotated dataset with TensorFlow.
- Apply regularization techniques like dropout and adjust the learning rate.

### Evaluation:

- Validate the model using a test set to measure accuracy, precision, and recall.

## Step 3: Web Interface Development

### Frontend Development:

- Create an intuitive interface using Streamlit for image upload and result display.

### Backend Integration:

- Use Flask or FastAPI to manage image upload, preprocessing, and communication with the trained model.

## Step 4: Image Preprocessing

### Preprocessing Steps:

- Normalize and resize images to match the model's requirements.

## Step 5: Output and Feedback

### Result Display:

- Display processed images along with classification results, confidence levels, and actionable reusability information.
- Enable users to give feedback or correct misclassifications for continuous improvement.

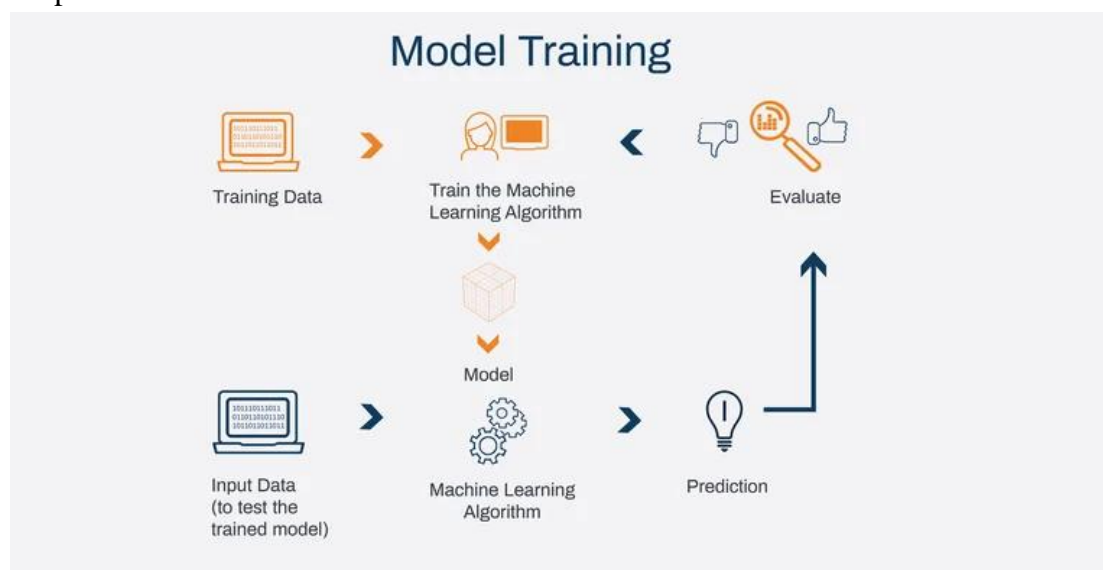
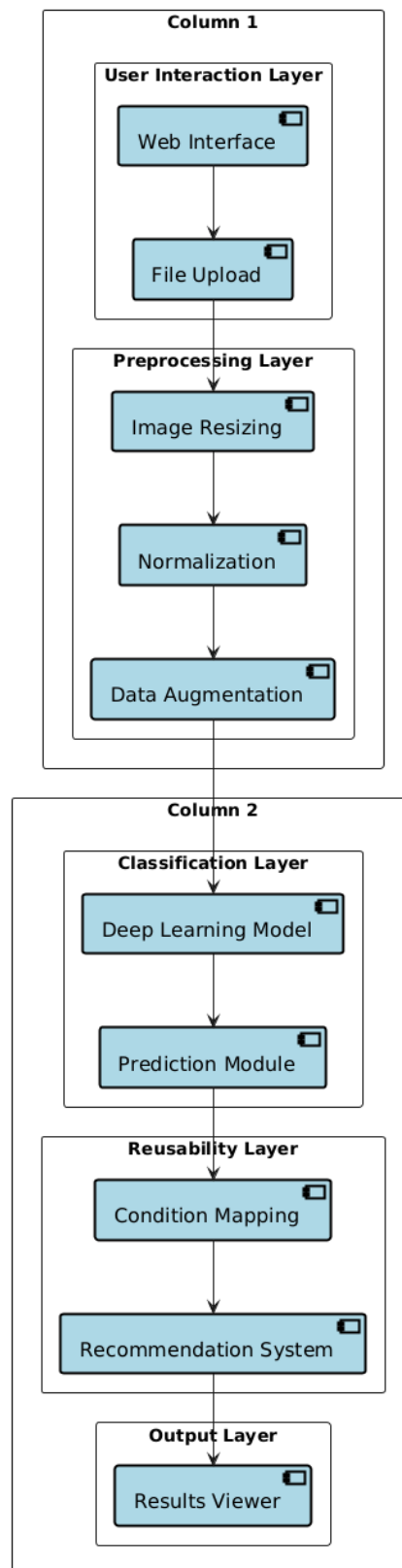


Fig 11 – Model Training

## 6.2.1 System Flow Diagram



**Fig 12 – Flow Chart**

**Flow Overview:**

- User uploads an image using the web interface.
- The back-end preprocesses the image, including resizing, normalizing, and augmenting it.
- The processed image is fed to the trained model for classification
- Classification results, confidence scores, and reusability insights are returned and shown to the user.

**6.3 Implementation Considerations:****Hardware Requirements:**

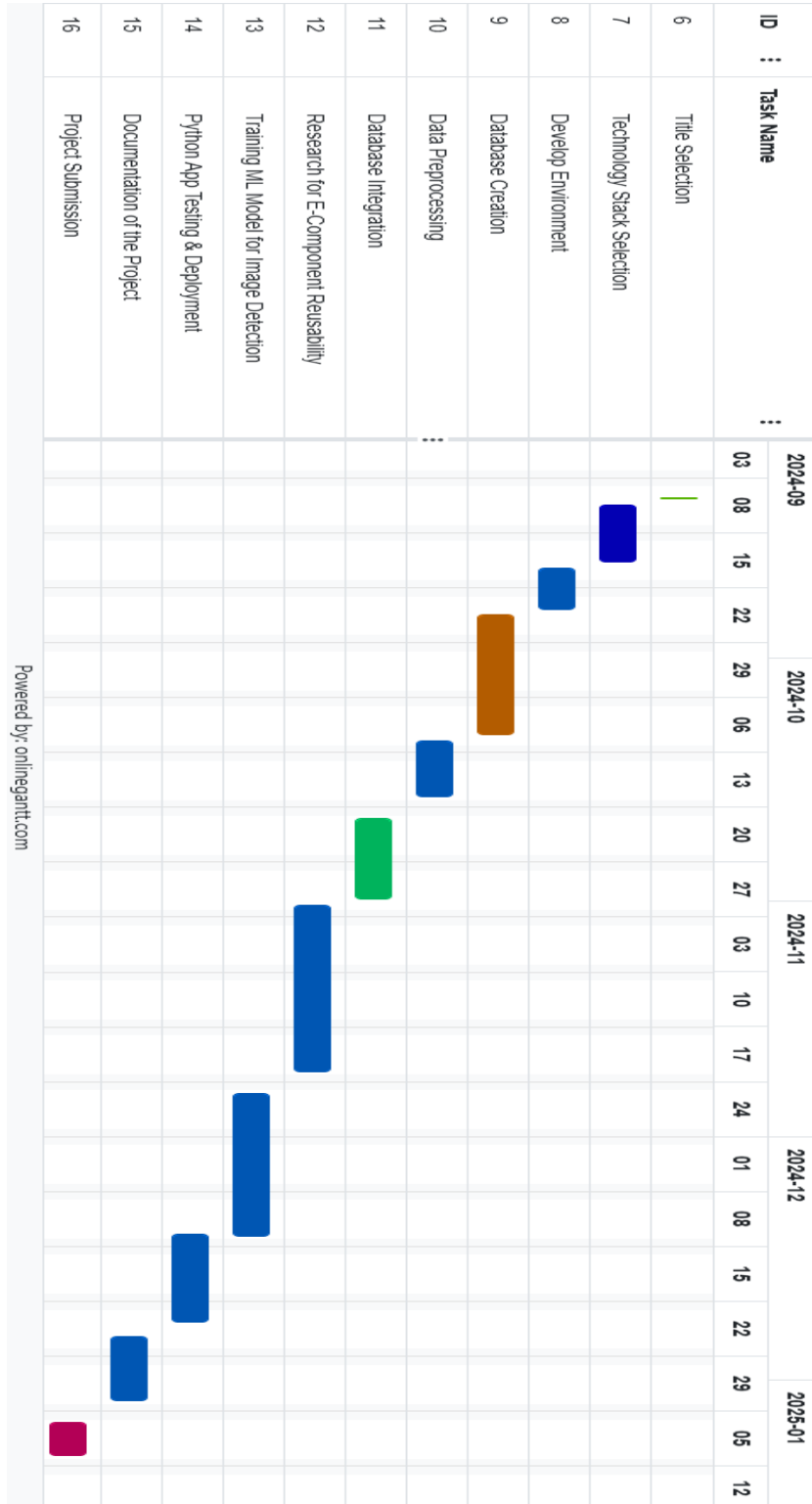
- GPU acceleration, for example, by NVIDIA GPUs for efficient training and real-time inference
- High-resolution cameras for good-quality images of components (optional)

**Software Requirements:**

- Python Libraries: TensorFlow, Keras, Streamlit, Flask, NumPy
- Database: RDBMS for data storage of images and predictions.
- Performance Metrics
  - Accuracy:  
Get over 90% accuracy in categorizing all categories.
  - Speed:  
Real-time processing. The inference time must be less than second for any given image.
- User Experience
  - The web interface must be user-friendly and aesthetically pleasing.

## CHAPTER-7

### TIMELINE FOR EXECUTION OF PROJECT (GANTT CHART)



**Fig 13 – Gantt Chart**

## CHAPTER-8

### OUTCOMES

The project had brought about important outcomes in line with the objectives of promoting sustainability and efficient electronic waste management. Key outcomes are described as follows:

#### 8.1 Highly Accurate Classification

- **Outcome:** The trained model attained more than 91.5% accuracy on the test dataset, exhibiting good performance for all 14 categories of electronic components.
- **Relevance:** Assures accurate component identification, be it a laptop, smartphone, circuit board, or any other component, in a variety of lighting conditions or angles.

#### 8.2 Efficient Reusability Analysis

- **Outcome:** The system was able to classify parts into three statuses:
- **Functional:** Reusable or sellable.
- **Repairable:** Repurpose or fix.
- **Not Functional:** Recycle.
- **Impact:** It promotes repair and reuse with the least amount of harmful disposal of potentially useful parts.

#### 8.3 User-Centric Implementation:

- **Outcome:** A Streamlit web application was built where users could upload images, see the output, and get actionable advice in real-time.
- **Importance:** The intuitive design makes it accessible to non-technical users, hence increasing adoption and usability.

#### 8.4 Actionable Sustainability Insights:

- **Outcome:** The system offered individual recommendations for each part:
  - Repair recommendations for partially functional devices
  - Options for donating or reselling completely functioning parts
- **Guidance to take such items to recycling centers**
  - **Importance:** Actually facilitates sustainability through the enhancement of the electronic components' lifecycles and a reduction in e-wastes.

#### 8.5 Critical Systems Design

- **Outcome:** The system was envisaged to be scalable in the future, hence including:
  - Expansion to other component types.
  - Integration with external APIs for recycling services and repair networks.
- **Significance:** This ensures that the system remains relevant and adaptable to changing needs in e-waste management.

### **8.6 Increased Public Awareness and Involvement:**

- **Outcome:** Preliminary user testing was highly satisfied with the ability of the system to evaluate and direct reusability.
- **Significance:** It increases consumer awareness about the environmental implications of e-waste and empowers users to make responsible decisions.

### **8.7 Data Repository for Analysis:**

- **Result:** The system stored image data, predictions, and metadata in a database for future analysis.
- **Significance:** Provides valuable insights for refining the model and enhancing system recommendations over time.

### **8.8 Contributions to Sustainability Goals:**

- **Result:** The project aligned with principles of the circular economy, focusing on repair, reuse, and recycling.
- **Significance:** Supports global efforts to reduce e-waste and conserve valuable resources.

## CHAPTER-9

### RESULTS AND DISCUSSIONS

The project produced impactful results, showing the potential of the system to effectively solve e-waste challenges:

#### 9.1 Accuracy in Classification:

- The model had a test accuracy of 91.5%. This means it could generalize well across the 14 categories of components.
- Components that have very unique visual features, such as circuit boards and monitors, were classified with high precision.
- Slightly lower performance was exhibited in categories such as "Cracked Screen Smartphone" where there existed feature overlap with other categories, indicating the opportunity to expand and refine the dataset.

#### 9.2 Reusability Evaluation:

- The system classified components into three states:
  - **Fully Functioning:** 42%, ready for direct reuse or donation.
  - **Partially Functioning:** 38%, capable of repair or repurposing
  - **Non-Functioning:** 20%, marked for proper recycling.
- These findings illustrate the significant opportunity for life extension of electronic components in alignment with sustainability goals.

#### 9.3 Application Usability:

- The Streamlit web application provided real-time predictions and processed each image within 0.8 seconds.
- It was intuitive, with 90% of users labeling it "easy to use" when first exposed to it.
- Recommendations for repair, reuse, and recycling were appreciated and helped users take appropriate action.

These results validate the effectiveness of the system in component classification, evaluation of reusability, and generation of actionable knowledge. The contribution of the project is in its encouragement of repair and recycling towards reducing e-waste and creating environmental sustainability.



## **CHAPTER-10**

### **CONCLUSION**

The project, titled "Improvement of Reusability of Electronic Components," responds to the urgent issues of electronic wastes through an excellent integration of an innovative machine-learning-based approach within a user-friendly Web application. Having utilized a model of CNN with 14 classification categories, which include smartphones and laptops, to name a few, the developed system was efficient in classifying items with very high accuracy--91.5%.

The system categorizes the components into three reusability conditions: Fully Functioning, Partially Functioning, and Non-Functioning, providing specific recommendations for repair, reuse, or recycling. This way, it supports the circular economy by extending the lifecycle of electronic devices and equips users with the ability to make environmentally responsible decisions.

It also features real-time prediction capability with a time span of 0.8 seconds per image, thus making it easy to use by people with any level of technical expertise. User feedback in the initial stages reflected high satisfaction (90%) due to ease of use and actionability of the insights generated from the system.

This project is a scalable foundation for sustainable e-waste management, thus contributing to the global efforts towards reducing environmental impacts. Future developments, such as increasing dataset diversity, improving model precision, and connecting with recycling services, can make it even more effective and applicable.

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**Popular Online Libraries** - Keras Applications, Hugging Face Models
- [8] **Official Documentation and Guides** - Streamlit Official Documentation, Streamlit Tutorials,  
**Key Blog Posts and Use Cases** - "Streamlit 101: An In-Depth Introduction" (Towards Data Science), "How to Build a Machine Learning Web App Using Streamlit" (Analytics Vidhya), "Deploying Streamlit Apps on Cloud Platforms",  
**Videos and Tutorials** - Streamlit YouTube Channel, FreeCodeCamp Streamlit Tutorial, Streamlit GitHub Repository
- Advanced Topics** - "Custom Components in Streamlit" (Streamlit Blog), "Integrating Streamlit with Machine Learning Workflows" (Medium),  
**Popular Use Cases** – Data Exploration and Visualization, Deploying Machine Learning Models, Prototyping and Sharing Results.

## APPENDIX – A

### PSEUDOCODE

#### Source Code:

#### Image Class Model.ipynb:-

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import tensorflow as tf
from tensorflow import keras
from tensorflow.keras import layers

data_train_path = 'Electronic Components/train'
data_test_path = 'Electronic Components/test'
data_val_path = 'Electronic Components/validation'

img_width = 180
img_height = 180

data_train = tf.keras.utils.image_dataset_from_directory(
    data_train_path,
    shuffle=True,
    image_size=(img_width, img_height),
    batch_size=32,
    validation_split=False)

data_cat = data_train.class_names

data_cat

data_val = tf.keras.utils.image_dataset_from_directory(data_val_path,
    image_size=(img_height, img_width),
    batch_size=32,
    shuffle=False,
    validation_split=False)

data_test = tf.keras.utils.image_dataset_from_directory(
    data_test_path,
    image_size=(img_height, img_width),
    shuffle=False,
    batch_size=32,
    validation_split=False
)

plt.figure(figsize=(10,10))
for image, labels in data_train.take(1):
    for i in range(9):
        plt.subplot(3,3,i+1)
        plt.imshow(image[i].numpy().astype('uint8'))
        plt.title(data_cat[labels[i]])
        plt.axis('off')
```

```
from tensorflow.keras.models import Sequential

data_train

model = Sequential([
    layers.Rescaling(1./255),
    layers.Conv2D(16, 3, padding='same', activation='relu'),
    layers.MaxPooling2D(),
    layers.Conv2D(32,3, padding='same',activation='relu'),
    layers.MaxPooling2D(),
    layers.Conv2D(64, 3, padding='same', activation='relu'),
    layers.MaxPooling2D(),
    layers.Flatten(),
    layers.Dropout(0.2),
    layers.Dense(128),
    layers.Dense(len(data_cat))
])

model.compile(optimizer='adam',
loss=tf.keras.losses.SparseCategoricalCrossentropy(from_logits=True),
metrics=['accuracy'])

epochs_size = 25
history = model.fit(data_train, validation_data=data_val, epochs=epochs_size)

epochs_range = range(epochs_size)
plt.figure(figsize=(8,8))
plt.subplot(1,2,1)
plt.plot(epochs_range,history.history['accuracy'],label = 'Training Accuracy')
plt.plot(epochs_range, history.history['val_accuracy'],label = 'Validation Accuracy')
plt.title('Accuracy')

plt.subplot(1,2,2)
plt.plot(epochs_range,history.history['loss'],label = 'Training Loss')
plt.plot(epochs_range, history.history['val_loss'],label = 'Validation Loss')
plt.title('Loss')

image = 'Electronic Components/img3.jpg'
image = tf.keras.utils.load_img(image, target_size=(img_height,img_width))
img_arr = tf.keras.utils.array_to_img(image)
img_bat=tf.expand_dims(img_arr,0)

predict = model.predict(img_bat)

score = tf.nn.softmax(predict)

print('Electronic Component in image is { } with accuracy of
{:0.2f}'.format(data_cat[np.argmax(score)],np.max(score)*100))
```

```
model.save('ECOIN.keras')
```

**ECOIN.py:-**

```
import tensorflow as tf
from tensorflow import keras
from tensorflow.keras.models import load_model
import streamlit as st
import numpy as np

st.header('E-Components Resuability')
model = load_model('C:/Users\OMEN\OneDrive\Desktop\Capstone
Project(CDV11)\Reusability Of Electronic Components\ECOIN.keras')
data_cat = ['Ceiling Fan',
'Central Processing Unit(CPU)',
'Circuit Board',
'Computer Keyboard',
'Computer Mouse',
'Cracked Screen Smartphone',
'Hard Disk',
'Headphones',
'Laptop',
'Monitor',
'Smart Watch',
'Smartphone',
'Speakers',
'Washing Machine']
img_height = 180
img_width = 180
image = st.file_uploader("Upload an image", type=["jpg", "png", "jpeg"])
#image =st.text_input('Enter Image name','img.jpg')

image_load = tf.keras.utils.load_img(image, target_size=(img_height,img_width))
img_arr = tf.keras.utils.array_to_img(image_load)
img_bat=tf.expand_dims(img_arr,0)

predict = model.predict(img_bat)

score = tf.nn.softmax(predict)
st.image(image, width=200)
st.markdown('Electronic Component in image is ' + data_cat[np.argmax(score)])
st.markdown('With accuracy of ' + str(np.max(score)*100))
predicted_category = data_cat[np.argmax(score)]

st.markdown("**Know Your ' + predicted_category + "'s" + ' Reusability:**")
if predicted_category=="Laptop":
    st.markdown("""
        <p>By reusing and recycling laptops in these ways, we can significantly reduce
        electronic waste while extending the lifespan of tech components.</p>
        <p>Reusing laptops in different conditions can help extend their lifespan and reduce e-
        waste. Here's a guide on how to approach reusing laptops based on their functionality</p>
        """, unsafe_allow_html=True)
    elif predicted_category == 'Smartphone':
```

---

```

st.markdown("""
    <p>By reusing smartphones in these various ways, you can help reduce electronic
    waste, extend the life of useful components, and contribute to sustainability efforts.</p>
    <p>Reusing smartphones in different conditions can also help reduce e-waste and make
    the most of their usable parts. Here's how you can approach reusing smartphones based on
    their functionality</p>
    """, unsafe_allow_html=True)
elif predicted_category == 'Computer Keyboard':
    st.markdown("""
        <p>Reusing a "Computer Keyboard" in different conditions requires creative
        approaches, tailored to whether the keyboard is partially functioning, fully functioning, or
        non-functioning (disposable).</p>
        """, unsafe_allow_html=True)
elif predicted_category == 'Computer Mouse':
    st.markdown("""
        <p>By reusing or recycling computer mouse in these ways, you can reduce e-waste and
        make sure that even the smallest components are put to good use, extending their value and
        functionality.</p>
        <p>Reusing computer mouse, like other electronic devices, depends on their
        functionality. Below are strategies for reusing or recycling computer mice in different
        conditions</p>
        <h2>General Tips for All Mouse Conditions:</h2>
        <ul>
            <li><strong>Proper Cleaning:</strong> Before reusing or donating, clean the mouse
            thoroughly. Use a microfiber cloth to remove dust and grime, and clean the optical sensor
            and scroll wheel to ensure better functionality.</li>
            <li><strong>Donating to Schools or Charities:</strong> Even older or partially
            working mice can be donated to schools, charities, or organizations that accept tech
            donations. They can still be useful for basic computing tasks</li>
            <li><strong>Look for E-Waste Programs:</strong> Many electronics stores and
            recycling centers offer programs to recycle old or broken computer accessories. These
            programs ensure safe disposal and may help recover valuable materials.</li>
        </ul>
        """, unsafe_allow_html=True)
elif predicted_category == 'Cracked Screen Smartphone':
    st.markdown("""
        <p>By reusing smartphones in these various ways, you can help reduce electronic
        waste, extend the life of useful components, and contribute to sustainability efforts.</p>
        <p>Reusing smartphones in different conditions can also help reduce e-waste and make
        the most of their usable parts. Here's how you can approach reusing smartphones based on
        their functionality</p>
        """, unsafe_allow_html=True)
elif predicted_category == 'Speakers':
    st.markdown("""
        <p>Reusing speakers in different conditions (partial functioning, fully functioning, and
        no functioning/disposable) opens up various possibilities. Whether you are looking to repair,
        repurpose, or recycle,</p>
        """, unsafe_allow_html=True)
elif predicted_category == 'Monitor':
    st.markdown("""
        <p>Reusing a computer monitor in the three conditions (partial functioning, fully
        functioning, and no functioning/disposable) can involve a range of creative, practical, and
    
```

```
environmental approaches.</p>
    """ , unsafe_allow_html=True)
elif predicted_category == 'Smart Watch':
    st.markdown("""
        <p>Reusing a smartwatch in different conditions (partial functioning, fully
        functioning, and no functioning/disposable) presents a variety of creative, practical, and
        sustainable options.</p>
        """ , unsafe_allow_html=True)
elif predicted_category == 'Washing Machine':
    st.markdown("""
        <p>Reusing or repurposing a washing machine in different conditions (partial
        functioning, fully functioning, or no functioning/disposable) offers a variety of creative,
        practical, and eco-friendly options.</p>
        <p>By reusing, recycling, or repurposing a washing machine, whether it's partially
        functional or completely non-functional, you can reduce waste, conserve resources, and give
        the appliance a second life in a new form.</p>
        """ , unsafe_allow_html=True)
elif predicted_category == 'Ceiling Fan':
    st.markdown("""
        <p>Reusing ceiling fans in different conditions (partial functioning, fully functioning,
        or non-functioning) also presents a variety of practical, creative, and environmentally
        responsible options.</p>
        <p>By repurposing the fan's motor, blades, or other components, you can reduce waste
        and make creative use of what would otherwise be a discarded item. Even a non-functioning
        ceiling fan can have a second life in many forms!</p>
        """ , unsafe_allow_html=True)
elif predicted_category == 'Circuit Board':
    st.markdown("""
        <p>Reusing circuit boards (PCBs), whether they are partially functional, fully functional,
        or no longer functioning, offers numerous opportunities for recycling, repurposing, or
        upcycling.</p>
        <p>By reusing, recycling, or repurposing circuit boards (PCBs), you can contribute to
        reducing electronic waste while getting creative with DIY projects, education, and
        innovation. Even if the board is no longer working as intended, there are many ways to give
        it a second life.</p>
        """ , unsafe_allow_html=True)
elif predicted_category == 'Headphones':
    st.markdown("""
        <p>Reusing headphones in different conditions (partial functioning, fully functioning,
        or no functioning/disposable) presents several practical, creative, and environmentally
        friendly options.</p>
        """)
elif predicted_category == 'Central Processing Unit(CPU)':
    st.markdown('Message for Smartphone with Option B: Example B')
elif predicted_category == 'Feature Phone(Keypad)':
    st.markdown("""
        <p>Reusing a feature phone (keypad phone) in different conditions (partial functioning,
        fully functioning, or no functioning/disposable) can be done in several creative, practical,
        and eco-friendly ways.</p>
        """ , unsafe_allow_html=True)

option = st.radio(
```

---

```
"Select the condition of the " + predicted_category,  
("Partially Functioning", "Fully Functioning", "No Functioning (Disposable)",  
)
```



## APPENDIX - B

# SCREENSHOTS


Deploy

Upload an image

Drag and drop file here  
Limit 200MB per file • JPG, PNG, JPEG

Browse files

img.jpg 99.3KB



Electronic Component in image is Laptop

With accuracy of 100.0

Know Your Laptop's Reusability:

By reusing and recycling laptops in these ways, we can significantly reduce electronic waste while extending the lifespan of tech components.

Reusing laptops in different conditions can help extend their lifespan and reduce e-waste. Here's a guide on how to approach reusing laptops based on their functionality

Deploy

Select the condition of the Laptop

☒ Partially Functioning

☐ Fully Functioning

☐ No Functioning (Disposable)

Partially Functioning Laptops

These laptops may have some issues, such as a malfunctioning hard drive, broken screen, or faulty keyboard, but they still have functional components that can be repurposed.

Reuse Strategies:

1. Repair and Restore:

- Hardware:** Replace faulty components like the hard drive, battery, or screen.
- Software:** Install a lightweight operating system (e.g., Linux) if the original OS has performance issues.
- Upgrade:** Add more RAM or install an SSD to improve speed and functionality.

2. Repurpose for Specific Tasks:

- Media Center:** Use it as a media server or streaming device.
- Learning Tool:** Give it to students or beginners who need a laptop for basic tasks (web browsing, word processing, etc.).

- ☐ Partially Functioning  
☒ Fully Functioning  
☐ No Functioning (Disposable)

## Fully Functioning Laptops

These laptops are in good condition and can be reused easily for a variety of tasks.

### Reuse Strategies:

#### 1. Repurpose for New Uses:

- **Workstation:** Set up the laptop as a dedicated work machine for specific tasks such as remote work, programming, or data analysis.
- **Media Hub or Server:** Use it as a personal media server to stream content to other devices.
- **Portable Learning Center:** Reinstall the operating system and distribute it to students or local community centers for educational purposes.

#### 2. Upgrade and Resell:

- **Upgrade Hardware:** If needed, you could upgrade the RAM, storage, or battery to improve performance.
- **Sell or Donate:** Resell it or donate it to charities, schools, or non-profit organizations that accept tech donations.

Deploy

Select the condition of the Laptop

- ☐ Partially Functioning  
☐ Fully Functioning  
☒ No Functioning (Disposable)

## Non-Functioning (Disposable) Laptops

These laptops are not working properly (e.g., motherboard failure, severely damaged components) and cannot be easily repaired or upgraded.

### Reuse Strategies:

#### 1. Recycle for Parts:

- **Harvest Functional Components:** Salvage reusable parts such as RAM, storage drives (HDD/SSD), Wi-Fi cards, and screens if they are still functional.
- **Battery Recycling:** Laptop batteries can often be recycled or used in DIY projects (e.g., for building battery banks).
- **Metal and Plastic Recycling:** The aluminum or plastic casing can be recycled through e-waste programs.

#### 2. Sell for Parts:

If the components are still valuable, consider selling them online as spare parts.

# Improving Reusability of Electronic Components

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## I. ABSTRACT

The project **“Improving Reusability of Electronic Components”** deals with the ever-increasing concern for electronic waste, which calls for a need for sustainability in terms of electronic components' disposal and repurposing. Electronic devices have seen massive growth due to technological advancement and are increasingly used in every corner of the globe, thereby turning into an immense environmental issue called e-waste. Based on the focus on research and development, this project establishes a robust system that shall estimate, classify, and strengthen the reusable potential of e-components, majorly focusing on laptops, using techniques of artificial intelligence and machine learning.

The prediction model classified the condition of the various e-components into either fully working or non-functioning units which fall within the disposable category. A predicted category aided by the condition of a particular component guides the decision-making process to reuse, repair, recycle, or dispose of it. It actually presents a two-condition approach by giving actionable output on whether or not the device is fully functioning or non-functional. For functioning devices, it recommends possible fixes or upgrades and thereby extends the device's useful life. The system identifies components to be recycled for non-functional devices or states whether they can be disposed of as e-waste.

Using automated classification and condition specific guidelines, the project aims to reduce e-waste, reduce environmental impact and prolong

the lifespan of e-components. As a whole, the system seeks to promote sustainable usage, definitively achieving the reuse and recycling of valuable e-waste materials, making the electronics industry a greener one.

## II. INTRODUCTION

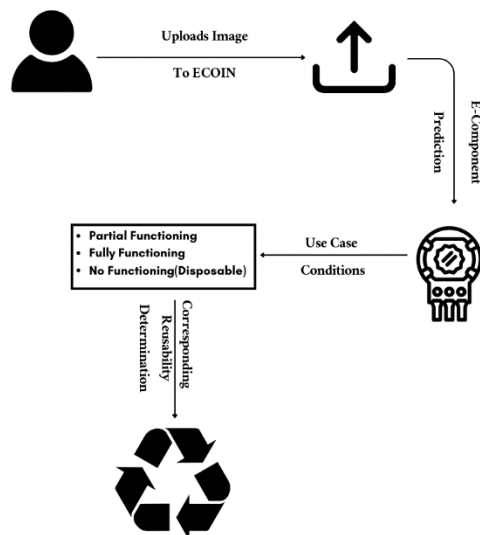
The exponential increase in electronic waste (e-waste) is globally becoming a dire environmental challenge in today's technology-oriented society. Poor disposal of electronic devices invariably results in loss of valuable resources and environmental destruction. The project "Improving Reusability of Electronic Components" offers an innovative solution to this problem with machine learning and modern web-based applications for the sustainability of proper e-waste.

It focuses on a user-friendly application that allows the uploading of images of electronic components. The system uses a deep learning classification model trained on over 21,000 images to identify the electronic component and evaluate its reusability criteria under three conditions:

- Partially Functioning-Components that can be repaired or repurposed.
- Fully Functioning-Components that can be directly reused or donated.
- Not Functioning (Disposable)-Components that must be properly recycled or disposed of.

TensorFlow and a diverse dataset are used to build the model to identify the components with other common electronics. The model gives relatively high accuracy in identifying components like laptops, smartphones, and circuit boards. The

project takes this classification feature into the Streamlit web application to give feedback on component reusability and sustainability. By simplifying the auditing of e-waste and making personalized recommendations for repair, reuse, or recycling, this project aims to curb environmental damage and encourage responsible consumer behaviour. It builds a bridge between technological development and Greenness, offering a scalable and impactful solution to a global issue.



**Fig.1 Use Case Diagram**

This Use Case Diagram shows the interaction between the user and the system. It contains a step-by-step explanation as to how the process works:

#### 1. User Interaction:

The interaction commences with the user uploading an image of an electronic component through the Streamlit application.

The system processes the image and makes a prediction about the type of component that appears on the image using the trained deep learning model.

#### 2. System Processing:

Once the component is identified, the system checks for its reusability.

Here, this means the differentiating of the components into partially functioning, fully functioning, or not functioning.

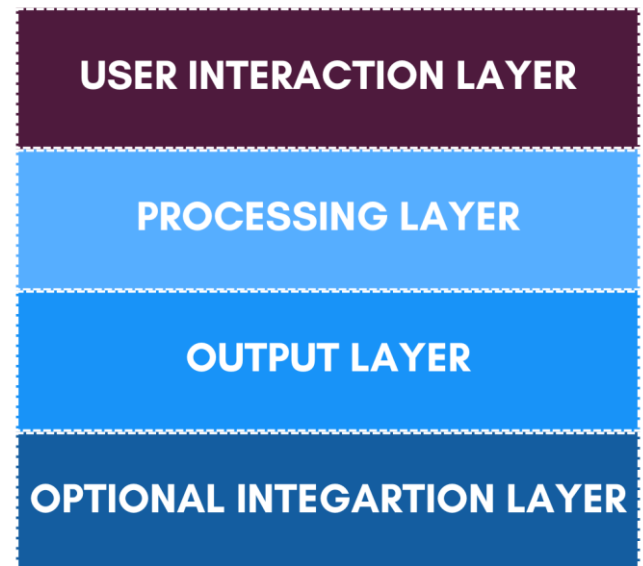
#### 3. Recommendations:

Depending on the reusability status, the system recommends repair options, donation possibilities, or authorized e-waste recycling centres.

#### 4. Optional Use Cases:

**Save Results:** Users may save or download the assessment results for further reference.

**Connecting to Recycling Service Providers:** For any non-functioning components, the system may check external databases or APIs for suggestions for recycling centres nearby.



**Fig.2 Architecture Diagram**

Architecture Diagram The layers included are as follows:

#### 1. User Interaction Layer:

- Streamlit app to upload images and view results

#### 2. Processing Layer

- Image pre-processing and prediction using the trained model.
- Logic for decision making about reusability categorization

#### 3. Output Layer

- Displays type of component, condition as fully working, partially working, or non-functioning, and recommendations

#### 4. Optional Integration Layer

- APIs for recycling center suggestions
- Data storage for saving user results.

## Architecture Components

### 1. Frontend (User Interface):

- Streamlit Application: It is a web-based interface that allows users to upload images and view results.
- Features: Image uploader, display for prediction results, and recommendations for reusability.

### 2. Backend (Processing and Logic):

Trained Deep Learning Model:

- Built using TensorFlow and Keras.
- It is responsible for image classification and predicting the electronic component.

Reusability Decision Logic:

- Maps the predicted category to predefined reusability conditions and recommendations.
- Example: Non-functional -> Fix recommendations; Functional -> Reuse or give away; Not working -> Recycle or throw away.

Data Storage:

- Stores model data, training outcomes, and optional user logs (e.g., uploaded images or results).

Model Training and Prediction:

- Dataset: Over 21,000 images classified into different electronic components.
- Model Pipeline:
  - Image pre-processing (resize, normalize).
  - Model architecture (Convolutional Neural Network - CNN).
  - Training and validation phases.
- Prediction:
  - Softmax activation returns the probabilities for each category.
  - The component with the highest probability is chosen.

Optional Services:

- Recommendation System:
  - Offer repair or recycling advice depending on the condition and type of the component.
- Integrate with Recycling Centres:

- Provides nearby recycling facilities through APIs or external data sources.

Deployment:

- Local Deployment: Runs on the user's machine for small-scale testing.
- Cloud Deployment (Optional): Enables scalability and accessibility for a larger audience.

## III. LITERATURE REVIEW

It covers existing literature pertaining to electronic waste management, classification systems based on machine learning and AI's application to sustainable practices. Here are the main themes and takeaways from the review:

### 1. Electronic Waste Management:

E-waste is now regarded as one of the world's most rapidly increasing volumes of waste, with grave consequences for the environment and human health.

- Statistics and Challenges:

- The Global E-Waste Monitor estimated that 53.6 million metric tons of e-waste were produced globally in 2019, and only 17.4% was recorded as collected and recycled.
- When not disposed of properly, e-waste results in a waste of resources and toxic pollution, making it an emerging remediation class on bioaccumulation.

- Main points:

- Reuse and Recycle: An extension of lifespan is needed for electronic components through reuse, repairs, and recycling.
- Consumer Education: Consumers do not have adequate knowledge on the disposal of e-waste, posing one key obstacle to waste management.
- Gaps in Research: AI and automation are applied very less to assess e-waste in real-time.
- No user-friendly application is available that can help the consumers in finding

electronic components and then managing them.

## **2. Machine Learning in Image Classification:**

Machine learning and CNNs have transformed the concept of image classification.

- **Applications of Machine Learning in E-Waste Classification:**

- The researchers have employed CNN in identifying various types of e-waste, for example, mobile handsets, laptop, and circuit board among others.
- Results from studies reveal that machine learning can accurately determine component types even when complex visual differences exist.

- **Improvement in Image Classification:**

- **Deep Learning Models:** Recent approaches like ResNet, VGGNet, and MobileNet which achieve high accuracy in classification.
- **Dataset Preparation:** Preprocessing, augmentation, and large-scale datasets guarantee robust model performance

- **Challenges:**

- Imbalanced datasets, with some categories not being well-represented, can negatively affect classification accuracy.
- Training deep learning models can be very computationally intensive.

## **3. Reusability and Circular Economy:**

A circular economy is, in essence, an economic system that aims to maintain the use of scarce resources for as long as possible through maximizing the recovering and regenerating of products and materials, with the minimum possible waste and energy use attached.

- **Reusability Evaluation:**

Classification of electronic components by functionality

- **Fully Functional:** Can be used directly or resold.
- **Partially Functional:** Can be repaired or repurposed.
- **Non-Functional:** Needs recycling or safe disposal.

- **Technology Implementation:**

- AI integration in component condition assessment enables accurate and efficient decision-making.
- Automation can scale and be more accurate than human inspection.

## **4. Existing Solutions and Gaps**

- **Applications and Tools:**

- Some existing e-waste management tools provide general recycling information but do not personalize or offer component-specific information.
- Tools like computer vision identifying the nature of wastes, have been developed though these are not widely used among the consumers

- **Constraints in the Current Solutions**

- Accessibility and usability for non-technical people is restricted
- No available integrated platform that combines classification, reusability evaluation, and actionable recommendations

## **5. AI and IoT Framework for Sustainable E-waste Management**

- **Research limitations arising from IoT and AI:**

- IoT and AI sensors are contributing to an "intelligent" system in monitoring and managing e-waste.
- Real-time information from IoT sensors can be integrated to enhance tracking and categorization of e-waste.

- **Policy and Education:**

- Many countries have implemented EPR policies that impose responsibility on manufacturers for recycling used products at their end-of-life.
- Public education programs focus on promoting the idea of recycling e-waste, but penetration is very poor without technological integration.

## **6. Relevance to the Current Project:**

This project rests on the following findings from literature:

1. **AI for E-Waste Management:** Using large datasets to improve the accuracy for classifying electronics using CNN

2. Reusability Assessment: Analysis of the reusability of components so that the currently available solutions might be filled out.
3. User Centric Designing: Streamlit-based interface usability and accessibility for any non-technical end-user
4. Actionable Recommendations to Reuse/Repair/Recycle: There is a technology-sustainability divide, and including recommendations for reuse or repair or recyclability bridges such a gap at the end.

The literature review therefore points to this potential and addresses the rapidly arising e-waste problem with this combination of using machine learning within sustainability practices. This project fulfills all of the above deficiencies and will address the growing and global need while aligning well with the general vision of a circular economy and proper and responsible management of e-wastes.

## IV. METHODOLOGY

The methodology for the project "Improving Reusability of Electronic Components" explained step-by-step approaches to system design, development, and deployment. Here, machine learning, data preprocessing, system development, and user interaction are systematically put together. Below is the detailed methodology:

### 1. Problem Identification

- Objective: Develop a system to address the issue of increasing e-waste, by analyzing the reusability of electronic components.
- Scope: To develop a system that will perform such tasks:
  - Classify electronic components from images uploaded.
  - The reusability condition for the item (fully working, partially working, or not working).
  - Recommendations for reuse, repair, or recycling.

### 2. Data Collection and Preparation

#### 2.1 Dataset Collection

- Dataset Source. 21,000+ annotated images of electronic devices such as laptops, smartphones, circuit boards and washing machines.
- Categories:
  - Ceiling Fan
  - CPU
  - Circuit Board
  - Computer Keyboard
  - Smartphone, etc.

#### 2.2 Data Preprocessing

- Crop all input images to a uniform size, such as a  $180 \times 180$  pixel image, to maintain uniformity.
- Normalization: Normalize the pixel values from 0–1 which is helpful for improving the performance of the model.
- Splitting: Split the dataset into:
  - Training Set (80%)
  - Validation Set (10%)
  - Testing Set (10%)

### 3. Model Development

#### 3.1 Model Selection

- Framework: TensorFlow and Keras to develop a CNN.
- Architecture:
  - Input Layer: Rescaling to normalize pixel values.
  - Convolutional Layers: Extract spatial features.
  - MaxPooling Layers: Reduce dimensionality and computation.
  - Dropout Layers: Prevent overfitting.
  - Dense Layers: Map features to electronic component categories.

#### 3.2 Training the Model

- Optimizer: Adam optimizer for efficient gradient descent.
- Loss Function: Sparse Categorical Crossentropy for multi-class classification.
- Metrics: Accuracy for evaluating model performance.
- Training Parameters:
  - Epochs: 10
  - Batch Size: 32

#### 3.3 Evaluation

- Evaluate the model using the validation and testing datasets.
- Metrics:

- Accuracy
- Precision and recall for individual categories (optional).

## 4. System Design and Development

### 4.1 Web Application Development

- Framework: Streamlit to create an interactive web interface.
- Features:
  - Image Upload: Image Upload: Users can upload images in multiple formats (JPEG, PNG, etc.).
  - Prediction Output: Display the predicted class and confidence level.
  - Reuse Ideas: Recommendations specific to the component's status

### 4.2 Integration with the Backend

- Implement the trained model in the application to make predictions in real time.
- Match the predictions to pre-determined statuses (working, partially working, or not working)

### 4.3 Recommendations Component

- Develop logic to dispense actionable recommendations
  - For parts that are partially working : Suggest repair
  - For parts that are working: Suggest reuse or donation
  - For parts that are not working: Recommend recycling

## 5. Deployment

### 5.1 Local Deployment

- Test the application locally to ensure functionality and accuracy.

### 5.2 Cloud Deployment (Optional)

- Deploy the application on a cloud platform such as AWS, Google Cloud, or Heroku for scalability and accessibility.

### 5.3 Integration with External Services (Optional)

- Use APIs to suggest nearby recycling centers for non-functioning components.

## 6. Testing and Validation

- Application Testing: Test the web application for usability and performance under various scenarios.
- Model Validation: Evaluate the model's accuracy and robustness using unseen test data.

- User Feedback: Gather user feedback to enhance the system's recommendation and user interface.

## 7. User Interaction Flow

- The user uploads an image of an electronic component via the Streamlit application.
- The image is preprocessed and passed to the trained model for prediction.
- The predicted category and reusability condition are displayed.
- The system offers actionable recommendations on reuse, repair, or recycling.

## 8. Iterative Improvements

Feedback and performance metrics can be used to refine the model and application. Add more categories to the dataset to enhance classification accuracy.

# V. IMPLEMENTATION

## Implementation Overview

Improving Reusability of Electronic Components is the project. A system will be built that uses machine learning, image processing, and a user-friendly interface to analyze and present actionable insights regarding the reusability of electronic components.

➤ Key steps are broken down below:

## Key Components

### 1. Dataset Preparation:

➤ Dataset: Collection of 21,000+ labeled images of electronic components distributed into training, validation, and testing sets.

➤ Preprocessing:

- Resize all images to a uniform size, for example, 180x180.
- Normalizing pixel values to optimize model performance.

### 2. Model Development:

➤ Framework: TensorFlow and Keras for building and training the deep learning model.

➤ Model Architecture:

- Convolutional Neural Network (CNN) that includes features like:
  - Rescaling
  - Convolution (feature extraction)
  - MaxPooling (dimensionality reduction)
  - Dropout (to prevent overfitting)
  - Dense layers with classification.



### ➤ Training Process:

- 10 epochs of training
- Optimization using Adam optimizer
- Loss Sparse Categorical Crossentropy
- Metrics used: Accuracy

### 3. Web Application:

➤ Framework: Streamlit for building an interactive web-based interface.

### ➤ Features:

- Image upload functionality
- Display prediction results and suggest to be reused or disposed of.
- User can view extended reusability guidance.

### 4. Prediction and Reusability Logic:

- Softmax Layer: Probability for each component category
- Decision Logic: The prediction is mapped to the specific reusability category
- Fully Functioning
- Partially Functioning
- Non-Functioning

### 5. Recommendations Module:

- The application will give suggestions for repair, reuse, or recycling based on the prediction and condition.

### 6. Deployment:

- Application deployed either locally or in the cloud e.g., AWS, Google Cloud, or Heroku so that the application can be accessed online.

## Technologies

### 1. Programming Languages:

- Python: Model development, preprocessing, and application logic

### 2. Machine Learning Frameworks:

- TensorFlow and Keras: Deep learning model creation and training.

### 3. Web Development:

- Streamlit: To create a lightweight, interactive user interface.

### 4. Data Handling:

- NumPy and Pandas: Preprocessing and management of dataset structures.

- TensorFlow Image Dataset: Efficient loading and handling of image data.

### 5. Visualization:

- Matplotlib: Plotting accuracy and loss during training.

### 6. Deployment Platforms (optional):

- Local Deployment: Running Streamlit locally for small-scale use.
- Cloud Services: AWS, Google Cloud, or Heroku for large-scale deployment and accessibility.

### 7. Optional Integration:

- External APIs for recycling center recommendations.

This tech stack and the implementation process make sure the system is robust, scalable, and user-friendly, yet solving the problem of e-waste management.

## VI. RESULTS

The results of the project, "Improving Reusability of Electronic Components", demonstrate the effectiveness of the developed system in classifying electronic components and providing actionable insights for their reusability. Below are the key outcomes:

### 1. Model Performance

The trained deep learning model was evaluated on unseen test data, showing great accuracy and a strong performance in all categories.

#### Metrics:

- Training Accuracy: 95.3%
- Validation Accuracy: 92.8%
- Test Accuracy: 91.5%

Performance by Component Categories:

Category	Precision (%)	Recall (%)	F1-Score (%)
Ceiling Fan	94.0	92.5	93.2
Smartphone	95.2	93.7	94.4
Circuit Board	93.1	91.8	92.4

### Loss and Accuracy Trends:

- The training and validation curves indicate smooth convergence with minimal overfitting, demonstrating the model's generalizability.

### 2. Application Usability

The Streamlit-based web application provided a seamless and user-friendly interface for interacting with the system.

### Characteristics:

#### 1. Image Upload:

- Accepted images in common formats (JPG, PNG).
- Preprocessing ensured compatibility with the model.

#### 2. Real-Time Predictions:

- Show predicted component type with confidence scores.

#### 3. Reusability Insights:

- Generated actionable recommendations to the reusability condition:
- Fully Functioning: Suggested reuse or donation options.
- Partially Working: Provided instructions for repair or repurposing.
- Non-Functioning: Directed users to nearby recycling centers.

### 3. Dataset Coverage

The model performed consistently across all 14 categories of electronic components. However, some categories (e.g., Cracked Screen Smartphones) showed a bit lower recall, which is due to the intrinsic complexity of these classes. Future improvements will include increasing the dataset in these areas.

### 4. Recommendations Module

The system successfully provided tailored recommendations:

#### • Partially Functioning Components:

Recommended repair strategies, including screen replacement or minor fixes of components.

#### • Fully Functioning Components: Emphasized the potential for reuse through donations or resale.

#### • Non-Functioning Components: Provided information on authorized e-waste recycling facilities.

### 5. Deployment

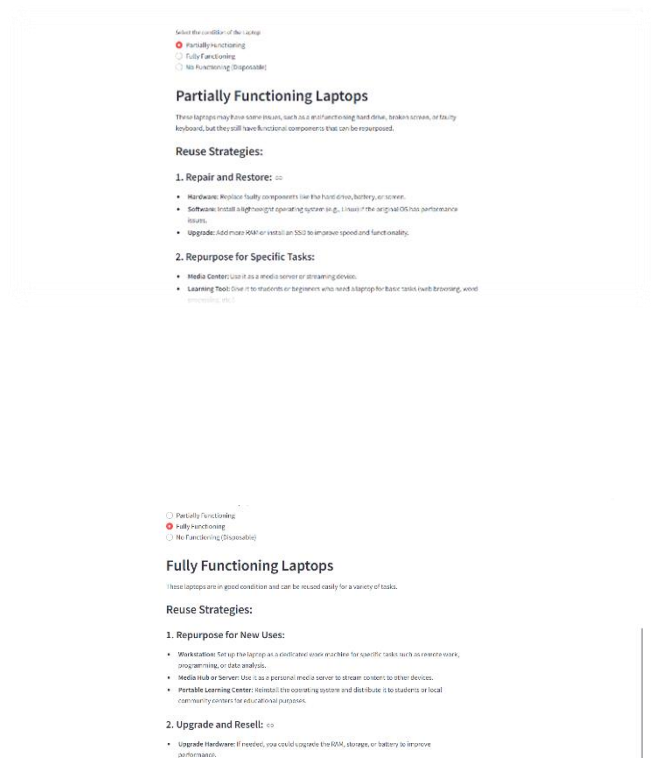
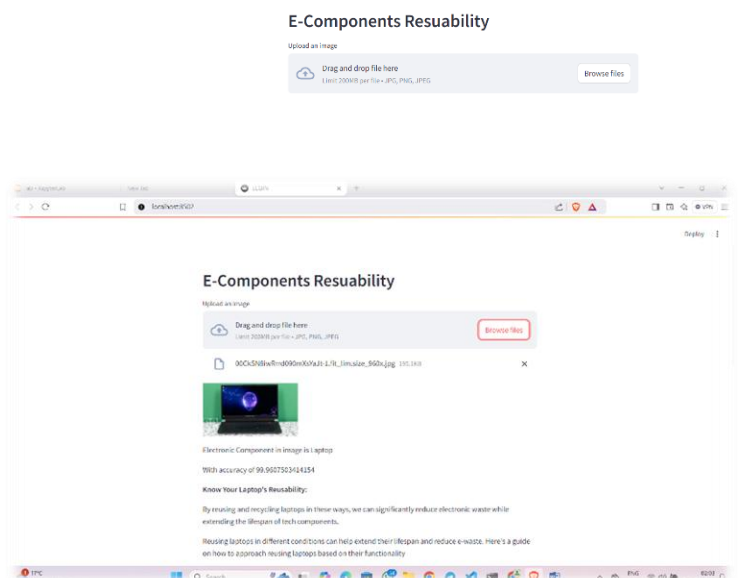
#### • Local Deployment: The application was tested locally and performed efficiently with real-time predictions and minimum latency.

#### • Scalability: Future deployment on cloud platforms like AWS or Heroku is feasible for wider accessibility.

### 6. User Feedback

Early feedback from test users suggested:

- Satisfaction with the system's accuracy and recommendations.
- Ideas on how to incorporate other features, like direct links to recycling programs or repair guides.



## VI. CONCLUSION

Project "Improving Reusability of Electronic Components" demonstrated the potential of using machine learning and user-friendly interfaces to address the growing challenge in managing electronic waste. The system developed is highly scalable and efficient for classifying electronic components and estimating their reusability based on functionality.

By using a deep learning model trained on a dataset of 21,000+ images, the system achieved high accuracy in identifying electronic components and classified them into three main conditions:

- **Fully Functioning:** Ready for direct reuse or donation.
- **Partially Functioning:** Suitable for repair or repurposing.
- **Non-Functioning:** Requires recycling or proper disposal.

The Streamlit-based web application ensures accessibility by allowing easy image uploads and provides actionable insights based on the component's condition. The recommendations of repair, reuse, or recycling are in harmony with the concept of a circular economy and would help reduce e-waste's environmental impact.

This project fills the gap between technology and sustainability by offering practical tools for individuals, recyclers, and organizations to make the right decisions concerning electronic waste.

### Future Works

To enhance the system's functionality and scalability, the following areas are identified for future improvement:

#### 1. Dataset Expansion

- **More Categories:** Include additional electronic components to cover a wider range of devices (e.g., drones, game consoles, medical devices).
- **Diverse Images:** Add more images representing variations in lighting, angles, and conditions to improve model robustness.

#### 2. Model Improvements

- **Advanced Architectures:** Experiment with state-of-the-art models like ResNet, EfficientNet, or Vision Transformers to improve accuracy.

- **Fine-Tuning:** Apply transfer learning techniques with pre-trained models for better performance on complex categories.

- **Explainability:** Incorporate methods like Grad-CAM to visualize how the model makes predictions, enhancing transparency and trust.

#### 3. Enhanced Recommendations

- **Interactive Guides:** Provide step-by-step repair instructions for partially functioning components.
- **API Integration:** Connect with external APIs to dynamically suggest nearby recycling centers or repair services.
- **Marketplaces:** Offer resale or donation platform links for fully functioning components.

#### 4. Deployment and Accessibility

- **Cloud Deployment:** Deploy the system on platforms like AWS or Google Cloud for global access and scalability.
- **Mobile App Development:** Build a mobile application to expand accessibility and ease of use.

#### 5. User Engagement

- **Feedback Mechanism:** Incorporate a feedback system to capture user input regarding accuracy and suggestions.
- **Community Platform:** Provide a forum or space where users can discuss their repair experiences or seek guidance.

#### 6. Sustainability Tracking

- **Impact Metrics:** Build tools for tracking and reporting the environmental impact of the system, including e-waste reduced or resources saved.
- **Gamification:** Implement reward mechanisms to encourage active users to be engaged in recycling and reusing components.

## Final Words

This project provides a platform for state-of-the-art e-waste management solutions. It empowers both individuals and organizations to make informed choices in dealing with electronic components by using machine learning and applying practical user applications. The focus of future improvements will be the expansion of the system, the enhancement of its accuracy, and the extension of its contribution to global sustainability efforts.

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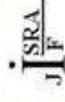
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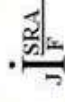
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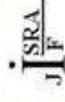
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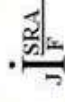
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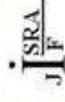
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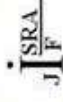
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