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Rupom Saha

The University of Newcastle

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# Executive Summary

The use of modern Communication devices is integral to our lives. We have more technological devices in our time than the number of humans on earth. These devices are bound to get into a lot of accidental malfunctions. Electronics Repair is a very complex, time consuming and money consuming process. The process also requires special knowledge and experience to execute.

Finding ways to preserve communication is very essential to our modern way of life. Repairing and recycling is crucial in the preservation of that modern means of interaction. In a world with rising numbers of AI and automated technology, it is time for our devices to be fixed automatically.

There are multiple mobile phone companies across the whole world. They all have their own blueprints for their products. Some require original parts for replacement, and some can be done with aftermarket products. Decisions of these repairs are challenging for the common person. As the new age of automation arises, we are bound to meet a turning point where phone repair and solutions are easier to automize than the touch of human error.

The concept of automated phone repair and maintenance is discussed in this paper. The methods involve developing a 3D model for the repair robot using Parametric CREO 9. Fault detection is tackled with using thermal and colour cameras and isolation from images in MATLAB.

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# Introduction

There are several challenges with the phone repairing process that needs to be addressed. In this project we will deal with the process of electronics repair and come to a modern innovative solution that involves automation. This project’s primary goal is to produce a system that can identify hardware faults, analyse, and rectify. There are also software faults that the report will suggest but will be delegated for future research.

The primary approach includes isolating a thought pattern of identifying damaged and unresponsive parts that will highlight the underlying problems with the device. There must be a prototype that can utilise the machine learning to produce a series of menial tasks that will save time in the long run. The program would suggest different solutions to all kinds of problems, starting from repair to the mother board to recycling and selling of parts. The program and device can search the internet with possible solution to repairs and damage.

The required diagnostics will involve all with the help of repair knowledge integrated with machine learning which can solve most repair problems. For repairs on complicated circuits like motherboard and PCBs it will require thermal imaging to seek damages precisely.

This paper will discuss all possible problems faced by smartphone customers that cannot be solved with a basic smartphone knowledge. Recycling and restoring damaged smartphones in a circular economy would benefit us in the future.

This topic is only the beginning of this discussion, as we discuss future possibilities of expanding these findings. We are to discuss various problems faced by the daily user that need expert help to solve. The project will focus on the circular economy of the smartphone industry into better repair and recycle habits. As technology evolves, the integration of artificial intelligence and automation in repair processes will become valuable to sustainability and reduction of electronic waste on our planet.

# Literature Review

## Existing Literature

### Thermal Imagining for PCBs

A phone’s motherboard is essentially a printed circuit board (PCB), so a whenever a part of the PCB fails or malfunctions, thermal cameras are used on a detect that problem. Engineers have figured to use thermal cameras to detect parts on a PCB that is overheating or not passing any current at all. “An Efficient Fault Detection Method for Induction Motors using Thermal Imaging and Machine Vision” ([Javed et al, 2022](https://www.proquest.com/docview/2700773020?parentSessionId=dnZfsi%2BI4aHhbaJYVM2rC9gYV%2BvVdlT7C0YxtiQGVyU%3D&pq-origsite=primo&accountid=10499&sourcetype=Scholarly%20Journals)) states the use of image thermography to look at induction motors while running. The thermal camera points out different parts of the induction motor and monitors any unusual temperature changes. This methodology can be similarly applied to PCBs in smartphone to ensure precise fault detection and efficient repair process.

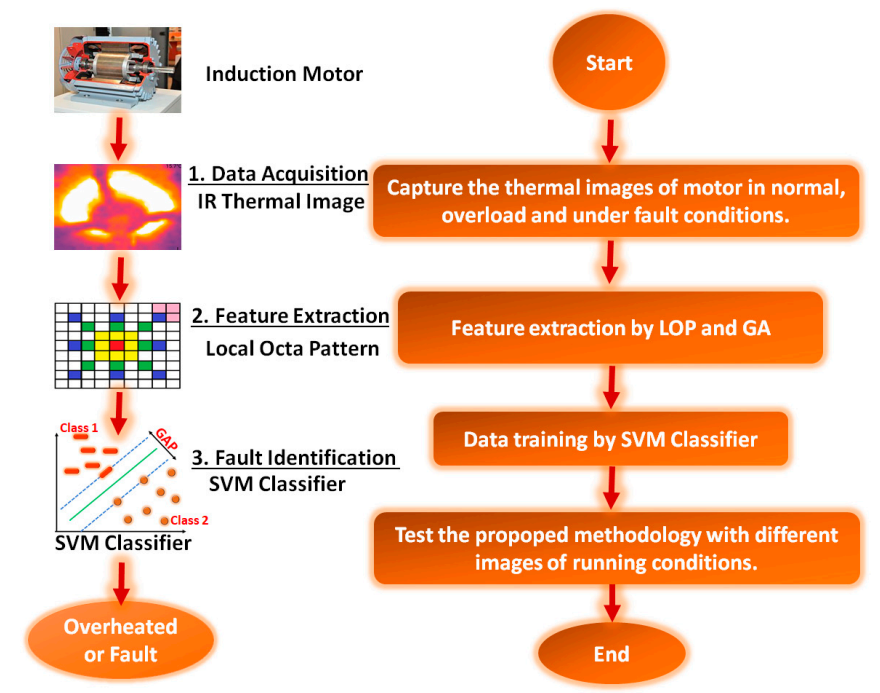


Figure 1: An Efficient Fault Detection Method for Induction Motors

### Automatic Diagnostics Device for Cars

An automotive is fitted with multiple sensors everywhere on its body, such as odometer, fuel gauge, engine sensors that monitor parameters like temperature and pressures of the engine, anti-lock braking system, etc. A device like OBD2 scanner is connect to a car by the port to test all the car sensors and run diagnostics ([Rimpas et al, 2019](https://www.sciencedirect.com/science/article/pii/S2352484719308649)).



Figure 2: Auto Diagnostic Scanner OBD2 and CAN https://www.supercheapauto.com.au/dw/image/v2/BBRV\_PRD/on/demandware.static/-/Sites-srg-internal-master-catalog/default/dw0f185e6f/images/590595/SCA\_590595\_hi-res.jpg?sw=1000&sh=1000&sm=fit&q=70

### The Importance of Repair and Recycle

As we get closer to global warming’s tipping point, we are more concerned about limiting our carbon footprint. Every single new production of increases our carbon footprint little by little that the time for this climate change disaster is irreversible.

Mobile phone parts contain numerous number of metals, some of these metals like cadmium, lead, chromium, mercury, etc are toxic ([Prabhu N et al, 2022](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9925901/#:~:text=Metals%20like%20cadmium%2C%20lead%2C%20chromium,et%20al.%2C%202020).)). Research suggests that e-waste is one of the fastest growing waste stream in the world ([Dhir et al, 2020](https://www.sciencedirect.com/science/article/pii/S0959652620343146)). To preserve our planet for future generations it is high time for us to address these issues.

### Electronics Repair using Artificial Intelligence

Using robotic arms and help is not new for the repair world. We use robots to perform multitude of tasks that are repetitive and cost effective to outsource. At the University of Bristol two researchers used a handheld robotic arm to tackle tasks that require maintenance, guidance and diagnostics ([Linder et al, 2019](https://www.popularmechanics.com/technology/robots/a29712497/robot-repair-arm/)). The robot has a remote controlled 5 degree of freedom tooltip that can be used in repair. The are also two cameras, one to observe the tooltip while operating, another to observe the workspace and anything else happening around the robot. The researchers mainly used the robot for midscale maintenance work, where a more expert worker can direct a rookie remotely and help in passing the knowledge.

### PCB Fault detection using Thermal Image Camera and Machine Learning

Integrating thermal imaging with machine learning greatly enhances fault detection efficiency and accuracy. Using thermal imagine, or thermology, identify overheating or insufficient heat dissipating components to collect data. The data then can be run through Convolutional Nural Network and Support Vector Machines to identify faults in high precision. Finding faults in soldering joints and monitoring overheating or underheating components. Automated Detection of Printed Circuit Boards (PCB) Defects by using Machine Learning in Electronic Manufacturing ([Zakaria et al, 2020](https://www.proquest.com/docview/2562143381?accountid=10499&parentSessionId=lYxthVBycHN6G6pD54Z8ju3Jg5%2FXU0egXu8veENfvKA%3D&pq-origsite=primo&sourcetype=Scholarly%20Journals)) discusses the possibilities in thermal imaging and machine learning on a large scale such as industries. The article by [Zhang et al (2021)](https://www.proquest.com/docview/2477373037?parentSessionId=ZFdY5dBM%2BgRpsG3a4OmPLnIvnyGTAZGN64Ijb8AKZCE%3D&pq-origsite=primo&accountid=10499&sourcetype=Scholarly%20Journals) discussed about training models to have an improved faster region-based convolutional neural networks (Faster RCNN) to handle solder joints defects in connectors.

### Predictive Maintenance using Machine Learning

In the automotive industry maintenance of vehicles are essential to the safety of society. Governments across the world suggests maintenance of cars at least once annually keeping track of its health to minimize any failures. In [Theissler et al (2021)](https://www.sciencedirect.com/science/article/pii/S0951832021003835) the researchers discuss about predictive maintenance (PdM) of automotives using machine learning. As we deal with the adaptation of humans into this exponential growth of technology, finding better solutions to maintenance is crucial, in automotives and smartphones.

### Identification of mobile phones using built in magnetometer.

Magnetometers are used to detect magnetic fields around them, measuring the strength, intensity, and direction. In numerous technological devices they are used for navigation and orientation using the earth’s magnetic field. Different phone models have distinctive shapes and different positions where the magnetometers are placed in them. Baldini et al (2017) discusses the uses of these magnetometer sensors that can identify these different smartphone models with high precision.

## Evaluation

### Key Findings and Analysis

Smartphone components are typically compact and required a dexterous touch. Working on delicate circuitry will need experience or robotic precision. The literature review suggests the extensive use of industrial mechanised robots to deal with repairs. Even though the repair process is extraneous, having a machine that can identify, isolate and solve each problem individually is of importance.

For component and software isolation deceive such as the OBD2 scanner are very useful to identify defects to an automotive’s hardware and software. Development of an automated device that can perform the same diagnostics for a smartphone.

Identifying different smartphone models and brands using a magnetometer is a promising literature review and method. With all different types of brands of smartphones, and all brands have multiple models that are released each year. A magnetometer sensor for identification is an important find.

The literature on thermal imagining is extensively used in industry to detect faults with components that are of varying sizes. Elements that use electricity all have resistance, which mean whenever current passes through them they resist some of it dissipating it to the surroundings as heat and sometime sound. If a component is resisting too much current and emits more than usual heat it is an indication of fault, on the other hand emission of less heat is an indication of the component not being used. Identifying faults in those components like capacitors and inductors can be the next step to solve a smartphone repair.

## Gap Identification

### Functional Robot Expense and Production Cost

Using precision robots are expensive to operate and maintain, which is why they are mostly used in medicine and research.

### Gap in Machine Learning and Artificial Intelligence

## Study Justification

### Motivation

A diagram of a diagram

Description automatically generated

Figure 2: <https://ars-els-cdn-com.ezproxy.newcastle.edu.au/content/image/1-s2.0-S0959652620356900-gr8_lrg.jpg>

### Benefits

By identifying users’ motivations and the barriers related to product repair, this research aimed to understand user perspectives to increase product [circularity](https://www-sciencedirect-com.ezproxy.newcastle.edu.au/topics/engineering/circularity).

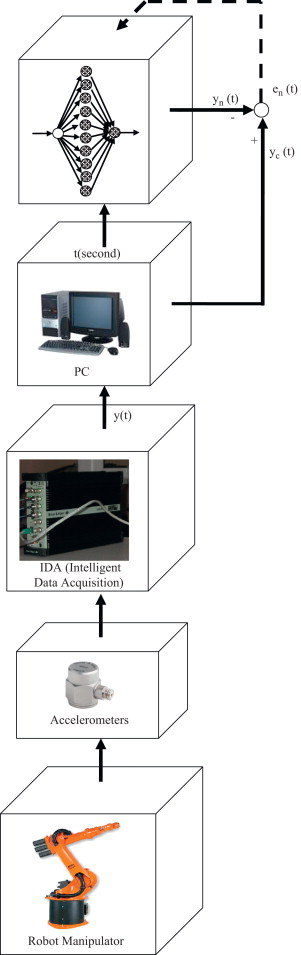


Figure 3: <https://www-sciencedirect-com.ezproxy.newcastle.edu.au/science/article/pii/S0736584510000682?via%3Dihub>

The use of thermal imagining can be used to find small parts in PCBs that are not operational and should be replaced.

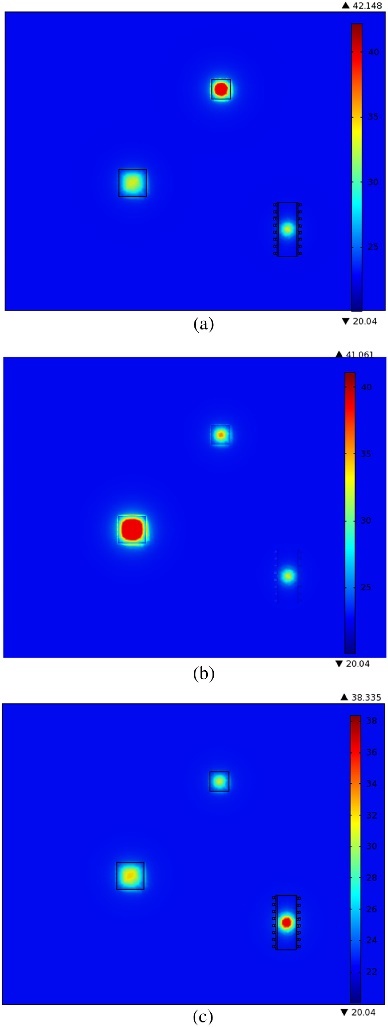


Figure 4: <https://www-sciencedirect-com.ezproxy.newcastle.edu.au/science/article/pii/S0026271417300367?via%3Dihub>

# Methodology

## Design

### Servo Arm

### 3.1.2 Fault Detection using Thermal Imaging

A diagram of a process flow

Description automatically generated

Figure 5: <https://www-sciencedirect-com.ezproxy.newcastle.edu.au/science/article/pii/S0026271417300367?via%3Dihub>

Repair process algorithm using thermal imagining.

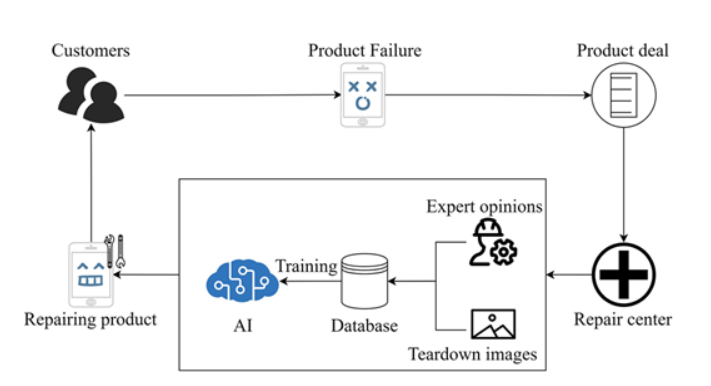
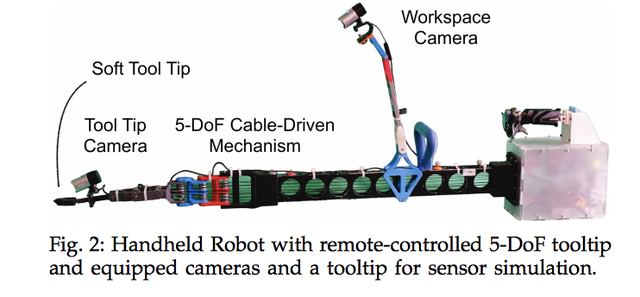


Figure 6: https://asmedigitalcollection-asme-org.ezproxy.newcastle.edu.au/manufacturingscience/article/146/2/020901/1167723/Automated-Evaluation-and-Rating-of-Product

The AI driven process to evaluate product repairability.

Use of this process is to get correct surveyed data from sources.



A black claw with a white background

Description automatically generated with medium confidence

As PCBs work on their function, depending on the power they consume, components on the PCB dissipates heat. Whenever a component on a PCB is not working, it is difficult to identify the damaged on unresponsive component by inspection. A thermal camera can identify components that gives off heat on the PCB.

### 3.1.3 Camera for Workspace Observation

Arranging a camera to watch over the workspace is important. Multiple cameras can observe repair process keeping an update on the work. The cameras can keep track of hazards and in most cases prepare for them ahead of time.

### 3.1.4 Automated Drill with Interchangeable Tips

A drill with an electromagnetic Endo factor, will allow the robot repair arm to be versatile. Since the process of phone repair requires multiple tools, being able to pick up and drop off different tool is essential. A motor that is equipped with an electromagnetic tip can pick up all different type of screwheads that is needed for a repair can be the answer. Being a robot that has the capability to change screwheads by itself, the robot can magnetize the motor tip with the screwhead needed and demagnetize when the specific repair step for a specific screwhead is finished.

### 3.1.5 Claw Phone holder with 6 Degrees of Freedom

Phones come in different widths, some also have curved or flap sides. A claw hand that can squeeze in two degrees of freedom can be a good design choice. The first degree of freedom can allow the claw to clamp on the phone to be repaired. The second degree of freedom is around the angular moment around the axis.

### 3.1.6 MATLAB Machine Learning toolbox for Fault Detection on Images

### 3.1.7 Automating Fault Detection Decision Making with State Machines

## Data Collection

### Repair Flowchart

During a repair process defects are to be recognized by the repairer and specific actions are taken to repair. Decision making is a massive part of machine learning, knowing how to make them requires data.

#### Isolating Possible Automatization Tasks

In the process of recycle and repair the repair consists of multiple decisions.

* Screen Replacement
* Battery Replacement
* Charging Port Replacement
* Earpiece Replacement
* Front Camera Replacement
* Back Camera Replacement
* Hacked

#### Possibly Unfixable Tasks

* Water Damage
* Back Plate and PCB snap

### Machine Learning Algorithm to Seek out Cracks on Phone Screen

## Recycle Procedure

## Analysis

## Limitations

### Cost

### Trust in Technology

### Commercialization

# Problem Statement

# Knowledge Gap

### 4.1.1 Vision Based Machine Learning

# Discussion

| **Research through design repair methods** | |
| --- | --- |
| **1** | 3D printing product parts |
| **2** | 3D printed patches |
| **3** | 3D printing pen |
| **4** | kintsugi (Traditional Japanese repair method employed to mend broken ceramics with gold and silver.) |
| **5** | kintsugi for textiles |
| **6** | Kintsugi-Sugru |
| **7** | darning |
| **8** | Darning-Sugru |
| **9** | Boro (A special way of repairing Japanese traditional clothes) |
| **10** | patching |
| **11** | Sugru patching |
| **12** | basket weaving |

# Recommendation

## Further Investigation

### 3D Printing Phone replaceable parts

### Training Artificial Intelligence into the Repair Process

## Method Improvement Suggestion

## Longitudinal Studies

## Practical Implications

### A Refurbished Phone or Laptop Selling Business

### Regular Low Budget Maintenance Company for Phones and Laptops

## Future Research Path Recommendations

### 6.5.1 Privacy matters with broken phones.

### 6.5.2 AI powered Phone Repair.

### 6.5.3 Phone Data extraction with biometrics security access.

### 6.5.4Phone Factory Reset Software/App for forgotten password.

### 6.5.5 Research for prediction about technology habits of generation Z when they are pensioners.

# Conclusion

There are multiple organisations and departments working on this topic of automated repair using machine learning.

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iPhone: The missing manual

<https://newcastle.primo.exlibrisgroup.com/discovery/fulldisplay?docid=cdi_globaltitleindex_catalog_168269747&context=PC&vid=61UON_INST:61UON&lang=en&search_scope=CentralIndex&adaptor=Primo%20Central&tab=CentralIndex&query=any,contains,mobile%20phone%20parts%20replacement%20with%20machine%20learning&offset=0>

Hybrid machine learning algorithms for fault detection in android smartphones

<https://onlinelibrary-wiley-com.ezproxy.newcastle.edu.au/doi/full/10.1002/ett.3272>

Remote repair, diagnostics and maintenance

<https://dl-acm-org.ezproxy.newcastle.edu.au/doi/abs/10.1145/1029496.1029501>

The right-to-repair movement: Sustainability and consumer rights

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This Robotic arm can lend a helping hand with repairs.

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Premium Mechanical Arm Claw with Servo for Robot Hand, Black Metal Robot Gripper Kit, RC Fingers Paw DIY Robotic Part Manipulator Clamp for Arduino, School Science Project, Experiment, STEAM

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# Appendix