Middlesex University London

Literature Review

CAN WE ACCURATELY IDENTIFY A PERSON USING AN INEXPENSIVE AI CAMERA?

[redacted]

CST 3990

Contents

1 Introduction

The interest in Artificial Intelligence technology has been greatly revived over the past years while new AI devices have been implemented and become easily available for purchase. (Shabbir and Anwer, 2018). AI based devices offer a range of different possibilities including but not limited to automating or improving tasks conducted by humans in day to day lives. (Donepudi, 2017). Mobile phone facial biometric security and Automated Border Control Systems (also known as E-Gates) are prime examples of what can be achieved using algorithms and trained data sets. Biometric approaches for security are one of the better methods that can be applied as each person's biometrics are unique to that specific individual and face characteristics can quickly be detected. (Kaur *et al,* 2020).

It is important to understand that there are challenges that even AI devices will struggle with, that will cause inaccuracies in the expected behavioural result of the system. With technology such as E-Gates, it is generally acceptable for the system to be inaccurate at verifying an identity of a person, in such cases where this happens, there is a backup in a form of immigration officer that will take control over the rest of immigration process. (Labati *et al.*, 2016). On the other hand, that is not the case with other uses of biometrics such as in mobile phones where there is no human activity that monitors what the system does and whether it is accurate. This raises a question whether security systems and other AI tools developed by organisations are secure enough to be trusted when they are deployed for mass use.

Husky Lens (Zhiwei Robotics, 2022) developed by DFRobot is an example of a cheap camera that can be purchased to detect people's faces. Looking at the effectiveness of an inexpensive device, it allows a better view of how technology has progressed in the means of AI and accurately identifying persons in real life scenarios. There are many issues that AI cameras can encounter when detecting faces and those include things such as luminance, depth of image, trained data set or the type of algorithm that has been used. This document will cover these key aspects which will be then taken into consideration when testing Husky Lens for its accuracy to determine whether cheaper AI devices such as the Husky Lens camera can be used for real life scenarios including non-intrusive AI surveillance of cities.

2 Literature Review

2.1 Face Recognition using Facial Features

In the research journal “Face Recognition Based on Facial Features” by Sharif, Javed and Mohsin (2012). The importance of accurately identifying a person in the image is emphasised. One of the methods being used is the colour space YCBCR with colour space normalisation technique. Using this technique, it is possible to obtain an outline of the person’s face, that is then mapped against the original picture.

Figure 1 represents the outcome of the YCBCR conversion. This approach omits participants hair as part of human’s external facial characteristics. The method used by Sharif, Javed and Mohsin (2012) has several flaws as for example the eyes are being detected as part of the noise that is surrounding the participant. This method is supposed to differentiate the background noise and facial characteristics, and it partially achieves this goal. To make use of this process for facial detection, another approach needs to be used called skin segmentation.

Figure 1: Extracted Skin, taken from Sharif, Javed and Mohsin (2012).

The method used by Sharif, Javed and Mohsin (2012) was based on luminance, the problem that comes with luminance is that it becomes difficult to differentiate a human from background if both things have the same type of lighting shining onto them. Checking how luminance can affect face recognition is what will be tested using the HuskyLens as part of the research project. Sharif, Javed and Mohsin have concluded that YCBCR conversion in conjunction with features extraction method is accurate at detecting facial features. Furthermore, when looking at their results table, it is clear to understand that the mouth and eyes are detected by their method within a time of no longer than 2 seconds and the accuracy of detection rate for all facial features is above 96%. In their research what they have failed to understand is their goal of how fast you can detect facial features while maintaining the highest level of accuracy.

Furthermore, the conclusion is partially incorrect as even though they have managed to have a high accuracy of detected facial features, they have ignored other facial features such as mouth to find out its processing time while other internal and external features such as the hair and ears were completely omitted. In addition, only mouth and eyes were tested for the processing time which causes a big error in the data for the overall processing time of an image as other facial features may take much longer to be detected than the ones mentioned in the results section of their research. Within the project, what will not be assessed is how fast the face can be detected as it is being done in real-time by HuskyLens camera. The effect of luminance affecting the overall accuracy of detecting human within an image will be examined.

2.2 Face Recognition with RGBD Camera

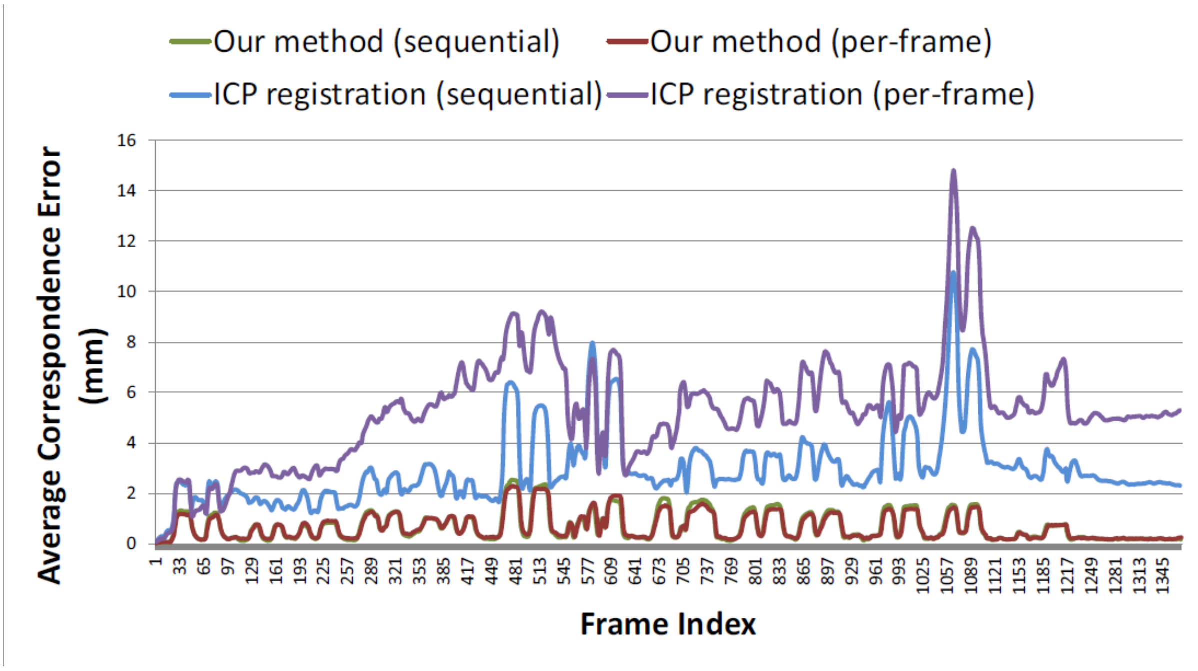


Figure 2: Average Correspondence Error, taken from Chen *et al* (2013).

Having depth of image sensor would improve detection accuracy results dramatically. Looking at Average Correspondence Error (Figure 2) from conference paper named “Accurate and Robust 3D Facial Capture Using a Single RGBD Camera” by Chen *et al.*, (2013), it is clearly shown that the ICP (Iterative Closest Point) registration algorithm has bigger spikes of errors as seen on figure 2 graph compared to their method that integrates a depth sensor. Husky Lens camera that is being used for the project uses neural network, but it does detect faces as they move which works similarly to the ICP registration algorithm where it compares images to define similarity in between them. This could potentially lead to similar results marked with a blue & purple line presented in the figure 2.

Using depth sensor such as the one of a Microsoft Kinect (Cong and Winters, 2019) is primarily needed to define the area that separates the human and the background. This is being achieved using infrared light or twin miniature cameras depending on what type of depth sensor is being used. Furthermore, it allows objects to be included within the area of the image that contains person. This plays a large role as during the analysis phase of the project as objects such as glasses or hats will be considered for the detection accuracy of the camera that will be tested.

Husky Lens contains a 2.0 Megapixel camera; it doesn’t contain a depth sensor. Chen *et al.*, (2013) discovered the importance of depth sensor while using Microsoft Kinect device. When using a depth sensor, it would be much easier to distinguish the difference between the background and the participant within this test, but because Husky Lens only has a pixel camera, it may find it much more difficult to focus on the main participant, especially when there is another person in the background. As previously mentioned, Javed and Mohsin (2012) have attempted to distinguish the multicoloured background from the human in an image using only computer-processed methods thus not having a depth sensor at all, and their results were not as accurate as expected until they have used additional algorithms to filter out the errors.

2.3 Detecting Unusual Human Activity Using AI

Sunil *et al.*, (2021) have emphasised the importance of increasing the number of iterations for the training model to improve its accuracy. Husky Lens device relies primarily on an already existing algorithm which is hard coded into the camera. Husky Lens contains an option of increasing as well as decreasing threshold for face detection but there is no publicly available information about how the threshold option works. It could be assumed that the camera reduces confidence level when using data set for the comparison. This results in lower accuracy when detecting the correct face from the list of previously learned faces but potentially reduces the time it requires to detect a face.

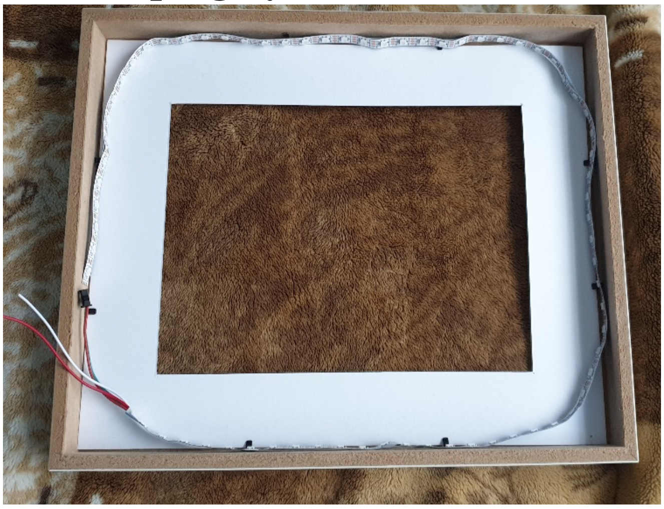
Single Shot Detector (SSD) is an effective algorithm that has been used by Sunil et al in their tests. The proposal tests the effectiveness of the system detecting a person wearing everyday clothing as well as the type of movement they are performing. Taking into an account that during the research project, an SSD algorithm won't be used, it is important to understand from Sunil et al paper that the higher iteration of training the data set results in much better accuracy of detecting an individual's facial features and activities. This raises a question whether inexpensive cameras such as the Husky Lens combined with well tested or/and well-trained algorithms could be implemented as daily surveillance systems for the benefit of safety of the public. This will be tested on the already existing data set built into the Husky Lens device. The conference paper lacks critical information that has been mentioned in the introduction. Specifically, the importance of finding out the detection speed against the number of iterations that the data set has been trained with.

2.4 Using Surveillance System as primary data for AI Image Processing

Nordmo *et al.*, (2021) describes the idea of using an artificial intelligence image processing system for surveillance and aid of preventing unauthorised fishing in ponds used by private fishing clubs. The system mentioned consists of basic surveillance camera that outputs data into an AI driven system. The software compares using an algorithm the pictures of people's faces and activities that have been already stored in the database. The method highlights its effectiveness with the preservation of individual's privacy, as the input from the person's side is limited to only difficult cases where the camera is unable to detect accurately by which human assistance is needed and the system to learn upon.

Privacy is an important aspect of a system that captures and stores a person's identity. Nordmo *et al.*, (2021) describes an AI surveillance as a very transparent system that is built to aid in detection of illegal and suspicious activities while maintaining a level of confidentiality as it reduces the feeling of the system being invasive in comparison to a traditional system of a man behind a camera. In addition, similarly to what Sunil *et al.*, (2021) has mentioned in his paper, the data set can constantly be trained to improve and adapt to new scenarios. The data needs to be protected as it's part of a person's identity when it is stored and likewise during the testing phase of the project, the storage of images of people's faces needs to be taken to an account under the Data Protection Act (2018) when it is being used for research purposes. The system presented by Nordmo is less intrusive and in return more secure, therefore if devices such as Husky Lens were to be used in daily cases to prevent illegal activities, they would benefit by keeping a great level of privacy and thereby preventing unnecessary issues regarding ethics and other questions that would have to be revised before deploying such systems.

3 Developing System



As stated by Sharif, Javed and Mohsin (2012), luminance plays a key role in detecting facial features due to limited differentiation between objects when they appear with similar brightness in front of a camera. Figure 3 represents an object which is a frame that contains one long strip of RGB LEDs. This apparatus has been developed to test recognition accuracy of individual's facial features with the effect of different luminance levels affected by the hue of the RGB strip.

Figure 3: LED Strip with Picture Frame

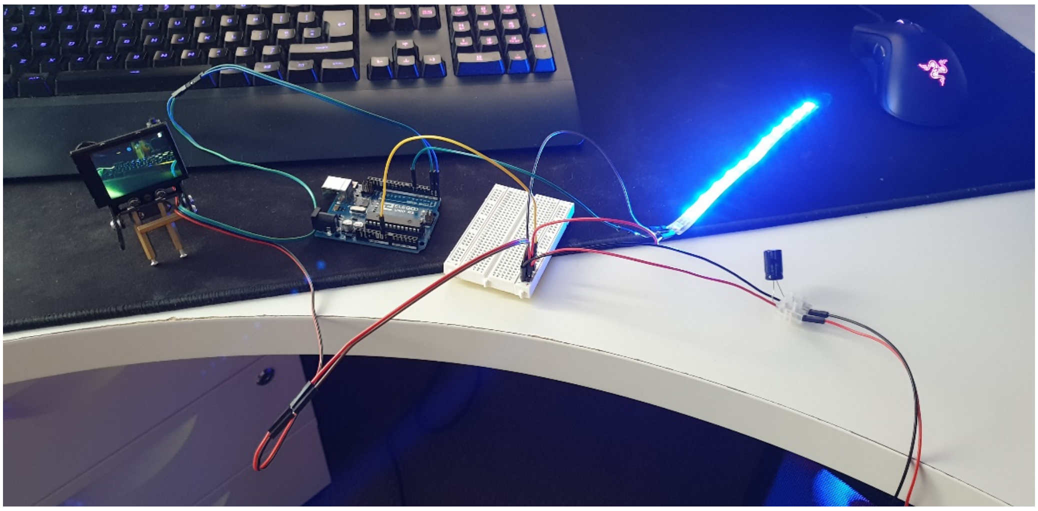


Figure 4: Arduino controlling RGB strip and collecting data from Husky Lens

Figure 4 represents an early stage of developing a system that utilises the RGB strip and Husky Lens camera which are controlled directly from the Arduino microcontroller. The proposed system will be able to test the accuracy of face detection under a range of different colours emitted from RGB strip. Once the prototype becomes fully functional, the RGB strip and its connections will be replaced with RGB strip attached to a Picture Frame represented in Figure 3 that a participant will hold for the research. Using frame with LED lights is a good approach to evenly distribute the light source around and onto the participant's face. This potentially will improve the accuracy of my testing as the results will be less impacted by the background light that caused an issue with face extraction method from the paper by Sharif, Javed and Mohsin (2012).

Data Protection Act (2018) states that any data that is being stored which contains personal details including images that could potentially identify a person are legally required to be stored securely. Micro card reader located on the Husky Lens will be used for collection of screenshots taken by the camera itself of each participant's face and after each successful test these screenshots will be transferred to cloud-based system such as OneDrive to securely store images of participant's faces.

```
void printResult(HUSKYLENSResult result){
    if (result.command == COMMAND_RETURN_BLOCK){
        Serial.println(String()+F("Block:xCenter=")+result.xCenter+F(",yCenter=")+result.yCenter+F(",wid
    }
    else if (result.command == COMMAND_RETURN_ARROW){
        Serial.println(String()+F("Arrow:xOrigin=")+result.xOrigin+F(",yOrigin=")+result.yOrigin+F(",xTa
    }
    else{
        Serial.println("Object unknown!");
    }
}
```

Figure 5 Obtaining Data from Husky Lens using Husky Lens Library

During the development of the prototype, it is clear to understand that using only Husky Lens camera as a main method of measuring the position of a participant's face would be difficult. Figure 5 shows a part of the Arduino code that is being used now in the project to measure where participant's face is located on the Husky Lens display using x and y coordinates of the screen. This may soon be changed in the project as it is not an effective way of detecting position due to for example a person tilting one way or being further away from the camera than it should. There is also a problem that each person has a different shape of their head and face which would make detection that is based using on-screen coordinates not very accurate for final testing. Chen *et al.*, (2013) has mentioned how the data results become much more accurate when a depth sensor is being used. As previously mentioned, Husky Lens does not have a depth sensor. Taking into measures that there are many variables that can affect the result such as the daylight while the camera is being tested, one way to obtain more accurate data is to use a lidar sensor which will measure the distance of the participant face from the camera lens before the system takes a picture.

```
if (!huskylens.request()){
    delay(displayDataDelay);
    strip.fill(strip.Color(55, 0, 0), 1, 12);
    strip.show(); // Initialize all pixels to 'off'
    delay(displayDataDelay);
    Serial.println(F("Fail to request data from HUSKYLENS, recheck the connection!"));
    strip.fill(strip.Color(0, 0, 0), 1, 12);
    strip.show(); // Initialize all pixels to 'off'
```

Figure 6 Controlling RGB Strips using Adafruit Neo Pixel library

RGB strips has an important role of controlling luminance within the research project. The aim of the RGB strip is to test whether the detection accuracy of a person will remain similar if there are different types of light colours that will shine onto a user's face. Figure 6 shows part of the code written for RGB strips by Adafruit (Burgess, 2013) that is being used to adjust RGB strip behaviour.

4 Conclusion

Based on the research that I have gathered and reviewed, luminance and the depth of an image that is being captured plays a huge role in accuracy of proposed research and its results. Taking into consideration all the material discussed in the literature review, it is certain for this research to proceed as there are not that many reports which cover the aspect of accurately identifying a person with an inexpensive AI equipment against effects of luminance and distance of images being taken. Furthermore, when assessing the quality of results found in research papers, some of the results have been inaccurately measured or even omitted which creates a gap for new research to be completed. In addition, testing inexpensive AI cameras for effectiveness to see how AI has advanced could result in such devices to gain more popularity and in return allow systems like the AI surveillance mentioned by Nordmo *et al.*, (2021) to be deployed for use in real world applications.

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Appendices

		Message
✔	⚑	Your application has been submitted.
✔	⚑	Your form has been signed b[redacted]
✔	⚑	Your Identify Specific Facial Features Using Camera has been upgraded

Research Ethics Screening Form for Students

Middlesex University is concerned with protecting the rights, health, safety, dignity, and privacy of its research participants. It is also concerned with protecting the health, safety, rights, and academic freedom of its students and with safeguarding its own reputation for conducting high quality, ethical research.

This Research Ethics Screening Form will enable students to self-assess and determine whether the research requires ethical review and approval via the Middlesex Online Research Ethics (MORE) form before commencing the study. Supervisors must approve this form after consultation with students.

Student Nam[redacted]		[redacted]
	Research project title: Can we Accurately Identify Specific Facial Features Using an Inexpensive Camera?	
	Programme of study/module: CST3990 Undergraduate Individual Project	
Supervisor Name[redacted]		[redacted]

Please answer whether your research/study involves any of the following given below:		
1. [H]ANIMALS or animal parts.	☐ Yes	☒ No
2. [M]CELL LINES (established and commercially available cells - biological research).	☐ Yes	☒ No
3. [H]CELL CULTURE (Primary: from animal/human cells- biological research).	☐ Yes	☒ No
4. [H]CLINICAL Audits or Assessments (e.g. in medical settings).	☐ Yes	☒ No
5. [X]CONFLICT of INTEREST or lack of IMPARTIALITY. If unsure see "Code of Practice for Research" (Sec 3.5) at: https://unihub.mdx.ac.uk/study/spotlights/types/research-at-middlesex/research-ethics	☐ Yes	☒ No
6. [X]DATA to be used that is not freely available (e.g. secondary data needing permission for access or use).	☐ Yes	☒ No
7. [X]DAMAGE (e.g., to precious artefacts or to the environment) or present a significant risk to society).	☐ Yes	☒ No
8. [X]EXTERNAL ORGANISATION – research carried out within an external organisation or your reseach is commissioned by a government (or government body).	☐ Yes	☒ No
9. [M]FIELDWORK (e.g biological research, ethnography studies).	☐ Yes	☒ No
10. [H]GENETICALLTY MODIFIED ORGANISMS (GMOs) (biological research).	☐ Yes	☒ No
11. [H]GENE THERAPY including DNA sequenced data (biological research).	☐ Yes	☒ No
12. [M]HUMAN PARTICIPANTS – ANONYMOUS Questionnaires (participants not identified or identifiable).	☐ Yes	☒ No

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13. [X]HUMAN PARTICIPANTS – IDENTIFIABLE (participants are identified or can be identified): survey questionnaire/ INTERVIEWS / focus groups / experiments / observation studies.	☒ Yes	☐ No
14. [H]HUMAN TISSUE (e.g., human relevant material, e.g., blood, saliva, urine, breast milk, faecal material).	☐ Yes	☒ No
15.[H]ILLEGAL/HARMFUL activities research (e.g., development of technology intended to be used in an illegal/harmful context or to breach security systems, searching the internet for information on highly sensitive topics such as child and extreme pornography, terrorism, use of the DARK WEB, research harmful to national security).	☐ Yes	☒ No
16. [X]PERMISSION is required to access premises or research participants.	☐ Yes	☒ No
17. [X]PERSONAL DATA PROCESSING (Any activity with data that can directly or indirectly identify a living person). For example data gathered from interviews, databases, digital devices such as mobile phones, social media or internet platforms or apps with or without individuals'/owners' knowledge or consent, and/or could lead to individuals/owners being IDENTIFIED or SPECIAL CATEGORY DATA (GDPR) or CRIMINAL OFFENCE DATA.	☒ Yes	☐ No
[X]PUBLIC WORKS DOCTORATES: Evidence of permission is required for use of works/artifacts (that are protected by Intellectual Property (IP) rights, e.g. copyright, design right) in a doctoral critical commentary when the IP in the work/artifact is jointly prepared/produced or is owned by another body	☐ Yes	☒ No
18.[H]RISK OF PHYSICAL OR PSYCHOLOGICAL HARM (e.g., TRAVEL to dangerous places in your own country or in a foreign country (see https://www.gov.uk/foreign-travel-advice), research with NGOs/humanitarian groups in conflict/dangerous zones, development of technology/agent/chemical that may be harmful to others, any other foreseeable dangerous risks).	☐ Yes	☒ No
19. [X]SECURITY CLEARANCE – required for research.	☐ Yes	☒ No
20. [X]SENSITIVE TOPICS (e.g., anything deeply personal and distressing, taboo, intrusive, stigmatising, sexual in nature, potentially dangerous, etc).	☐ Yes	☒ No

M – Minimal Risk; X – More than Minimal Risk. H – High Risk

If you have answered 'Yes' to ANY of the above questions, your application REQUIRES ethical review and approval using the MOREform **BEFORE commencing your research**. Please apply for approval using the MOREform (https://moreform.mdx.ac.uk/). Further guidance on making an application using the MOREform can be found at: www.tiny.cc/mdx-ethics.

If you have answered 'No' to ALL of the above questions, your application is Low Risk and you may NOT require ethical review and approval using the MOREform before commencing your research. Your research supervisor will confirm this below.

Student Signature:..........[redacted].............. Date: ..[redacted]