Skin Cancer AI

A capstone project report submitted in partial fulfilment of the requirement for the award of the degree of

Bachelor of Engineering

in

Electronics and Computers Engineering

Submitted By

Tanmay Garg (Regn. No. 101915001)

Avneet Singh Maingi (Regn. No. 101915005)

Aditya Chawla (Regn. No. 101915018)

Aakarshan Gupta (Regn. No. 101915050)

Akshit Gupta (Regn. No. 101915051)

(Group No – 9)

Under Supervision of

Dr. Rahul Upadhyay (Associate Professor, ECED)

Dr. Vinay Kumar (Associate Professor, ECED)

Department of Electronics and Communication Engineering

THAPAR INSTITUTE OF ENGINEERING & TECHNOLOGY, PATIALA, PUNJAB

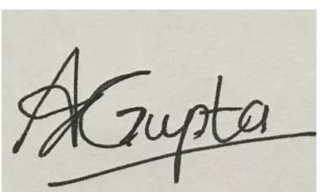
December 2022

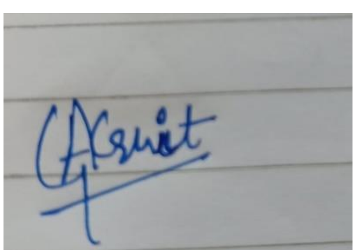
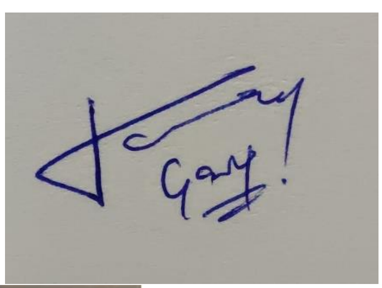
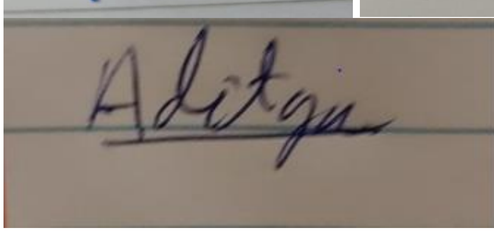
DECLARATION

We hereby declare that the capstone project group report title “Skin Cancer AI “is authentic record of our own work carried out at “Thapar Institute of Engineering and Technology, Patiala” as a Capstone Project in seventh semester of B.E. (Electronics & Communication Engineering), under the guidance of **“Dr Vinay Kumar and Dr Rahul Upadhyay”**, during January to December 2022.

Date: 10th August, 2022

Signature of Students:



ACKNOWLEDGEMENT

We would like to express our thanks to our mentor Dr Vinay Kumar and Dr Rahul Upadhyay. They have been of great help in our venture, and an indispensable resource of technical knowledge. They are truly an amazing mentor to have.

We are also thankful to the entire faculty and staff of Electronics and Communication Department, and also our friends who devoted their valuable time and helped us in all possible ways towards successful completion of this project. We thank all those who have contributed either directly or indirectly towards this project.

Lastly, we would also like to thank our families for their unyielding love and encouragement. They always wanted the best for us and we admire their determination and sacrifice.

Date: 10th August, 2022

Roll No.	Name
101915001	Tanmay Garg
101915005	Avneet Singh Maingi
101915018	Aditya Chawla
101915050	Aakarshan Gupta
101915051	Akshit Gupta

ABSTRACT

This project aims at building by detecting cancer at earlier stages. The survival rate for early detection of skin cancer is almost 98 percent, but it falls to 62 percent when the cancer reaches the lymph node, and 18 percent when it metastasizes to distant organs. Skin cancer develops primarily on areas of sun-exposed skin, including the scalp, face, lips, ears, neck, chest, arms and hands, and on the legs in women.

The building block of this detector is deep learning which is used to process an image, then recognize it and show the output accordingly. The hardware implementation is done using Raspberry Pi Model 3B+, Intel® Movidius™ Neural Compute Stick, SD card, Camera, USB cables etc. The picture will be received by the camera, and processing will be done inside the Raspberry Pi Model 3B+ & the Intel® Movidius™ Neural Compute Stick will do the heavy lifting and the output will be displayed on the monitor. The goal is to build a machine learning algorithm that can detect cancer images and pair it with mentioned hardware.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1) INTRODUCTION-

1.1 Project Overview-

Skin cancer is seen as one of the most hazardous form of cancers found in humans. Skin cancer is the abnormal growth of skin cells. It's a common cancer that can form on any part of the body, but it often occurs on sun-exposed skin. The survival rate for early detection in case of skin cancer is almost 98 percent, but it falls to 62 percent when the cancer reaches the lymph node, and 18 percent when it metastasizes to distant organs, we want to resolve this problem by detecting whether the cancer is malignant or benign. The building block of Skin Cancer AI detector is deep learning which is used to process an image, then recognize it and show the output accordingly. TensorFlow and Keras are used to build and create a machine learning model. Using Convolutional Neural Networks, we developed algorithms and models to distinguish between benign and malignant skin cancers.

Figure 1.1- Skin Cancer Statistics Source: Blue Scan Labs

Hardware Used:

- Raspberry Pi Model 3B+
- Intel® Movidius™ Neural Compute Stick
- SD card, Camera, USB cables and Keyboard

1.2 Motivation-

One of the major reasons behind the high fatality rate due to skin cancer is late detection of it which in turn leads to late diagnosis and then it becomes almost impossible to cure it. When the cells become cancerous, they can slowly spread to other parts of the body if left untreated. Melanoma: This very serious form of skin cancer can spread to other parts of the body and be deadly, if not diagnosed early. Early diagnosis is important for effective treatment. The survival rate for early detection in case of skin cancer is almost 98 percent, but it falls to 62 percent when the cancer reaches the lymph node, and 18 percent when it metastasizes to distant organs. There have been several experiments and studies to demonstrate and prove this fact that AI support can improve the overall accuracy of the dermatologists in the dichotomous image–based discrimination between melanoma and nevus. This supports the argument for AI-based tools to aid clinicians in skin lesion classification and provides a rationale for studies of such classifiers in real-life settings. A comparatively new strategy falling within the realm of computer-aided diagnosis (CAD) is the use of trained convolutional neural networks (CNNs) to analyze macroscopic images of suspicious lesions. Studies have shown that, within certain limitations and considering a purely image-based setting, artificial intelligence (AI) can achieve on par or superior performance to dermatologists, thereby highlighting its potential as a decision-support system with immediate clinical implications. We found a great rising in the trends of skin cancer AI detection systems, but still there is space for further improvement in present measures of skin cancer AI detection systems.

1.3 Assumptions and Constraints-

Assumptions and constraints associated with the project are discussed in the following table:

Table 1.1

S.No.	Constraints
1.	For the model to work with good accuracy a small dataset would not work. We used a dataset of 5k+ images.
2.	The training of thousands of images requires high computational power. Uneasy access to such computers is also one constraint.
3.	The user needs to write a line of code at the terminal to get the result displayed on the output device.
4.	The Skin cancer detection system AI software can only tell if a given image is cancerous or not. if the mole is not due to cancerous the AI software lacks the ability to identify the other reason behind it.
5.	Capturing an image and then it’s processing by Raspberry Pi and Neural Compute stick can be time consuming, therefore time is a constraint.

Table 1.2

S.No.	Assumptions
1	Moles on the skin must be within the range of the Camera.
2	The user needs to write a line of code that should be accurate to get the result displayed on the output device.
3	Camera assumed to be at a proper height.

1.4 Novelty Of Work-

There exists many AI based detection systems which use Machine Learning techniques as their fundamental base for the working of the project. With the expansion of technology, image based detection systems are attracting more attention. Machine learning (ML) requires feature extraction and model training. The major difference between traditional ML and deep learning is in the feature engineering. Traditional ML uses manually programmed features, where deep learning does it automatically. Feature engineering is relatively difficult since it requires domain expertise and is very time consuming. Deep learning requires no feature engineering and can be more accurate. We aim to make Skin Cancer Detection System with a high accuracy in order to identify cancerous cells as fast and efficiently as possible.

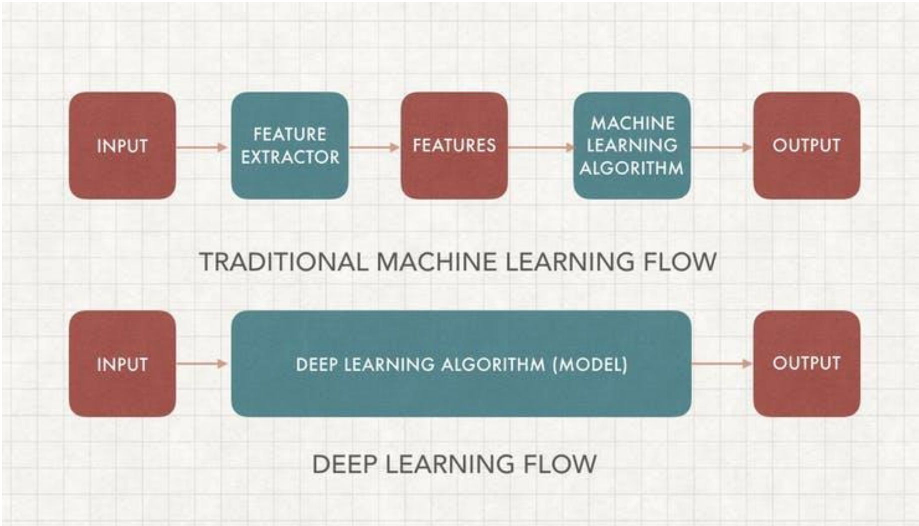


Figure 1.2- Traditional Machine Learning vs. Deep Learning

2) LITERATURE SURVEY-

2.1 Literature Survey-

Skin cancer — the abnormal growth of skin cells — most often develops on skin exposed to the sun. But this common form of cancer can also occur on areas of your skin not ordinarily exposed to sunlight. There are three major types of skin cancer — basal cell carcinoma, squamous cell carcinoma and melanoma. You can reduce your risk of skin cancer by limiting or avoiding exposure to ultraviolet (UV) radiation. Checking your skin for suspicious changes can help detect skin cancer at its earliest stages. Early detection of skin cancer gives you the greatest chance for successful skin cancer treatment. Skin cancer develops primarily on areas of sun-exposed skin, including the scalp, face, lips, ears, neck, chest, arms and hands, and on the legs in women. But it can also form on areas that rarely see the light of day — your palms, beneath your fingernails or toenails, and your genital area. Skin cancer affects people of all skin tones, including those with darker complexions. When melanoma occurs in people with dark skin tones, it's more likely to occur in areas not normally exposed to the sun, such as the palms of the hands and soles of the feet. Most skin cancers are preventable. To protect yourself, follow these skin cancer prevention tips:

- Avoid the sun during the middle of the day
- Wear sunscreen year-round
- Wear protective clothing
- Avoid tanning beds
- Be aware of sun-sensitizing medications

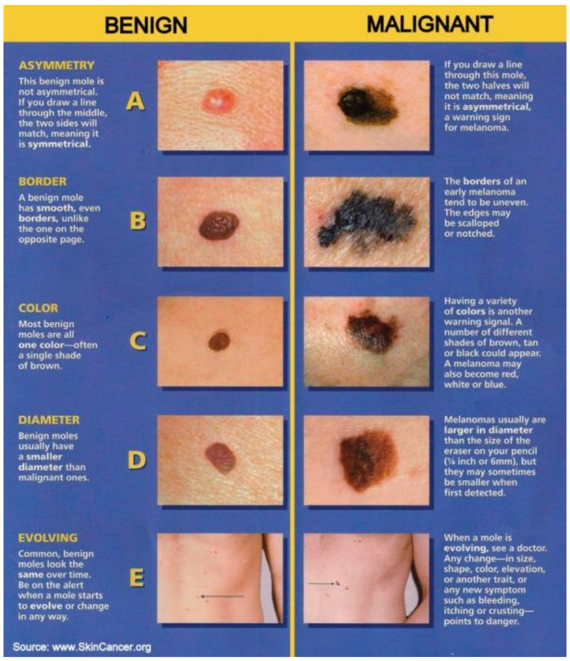


Figure 2.1- Benign Vs Malignant

2.1.1 Theory Associated with Problem Area-

- Skin cancer is seen as one of the most hazardous form of cancers found in humans. Skin cancer is the abnormal growth of skin cells.

- It's a common cancer that can form on any part of the body, but it often occurs on sun-exposed skin.

- According to the Skin Cancer Foundation, half of the population in United States are diagnosed with some form of skin cancer by age 65. The survival rate for early detection is almost 98%, but it falls to 62% when the cancer reaches the lymph node and 18% when it metastasizes to distance organs. With Skin Cancer AI, we want to use power of artificial intelligence to provide early detection as widely as available.

2.1.2 Sample Table for Literature Survey-

Introduction to Skin Cancer-

Skin cancer is a dangerous and widespread disease [1] Each year there are approximately 5.4 million new cases of skin cancer are recorded in USA alone [2], [4].The global statistics are equally alarming [3][5]. Recent reports show that from 2008 to 2018, there has been a 53% increase in new melanoma cases diagnosed annually [1,4]. The mortality rate of this disease is expected to rise in the next decade. The survival rate is less than 14% [[8], [9], [10]] if diagnosed in later stages. However, if the skin cancer is detected at early stages, then the survival rate is nearly 97% [3]. This demands the early detection of skin cancer.

Models and Algorithms-

The steps for constructing a deep learning model are listed below:

- Select the input block, drag and drop it into the work space.
- Perform some normalization (if required, drag & drop related blocks)
- Apply Convolution blocks (Choose activation ReLU preferably)
- Apply Pooling Blocks
- Apply Dropout block
- Repeat 3, 4, & 5 as many times as optimally needed
- Use some flattening block
- Use some core layers (Dense blocks preferably). Ensure here that final core layer before the output block has the proper output value parameter as per the data (output) categories.
- Apply the output block.
- Set the model parameters (Hyper parameter setting).
- Finally, ensure that the Model construction checks Green "OK" else fine-tune your selections.

Methodology-

The DLS, Model Driven Architecture Tool provides Neural Network Modeling components as a stack of drag-drop & develop art. The sequence of important general steps involved as a research methodology in this paper are as follows:

- Data Preparation
- Creating a project and loading the dataset
- Building a deep learning classifier
- Tuning the model
- Checking result
- Drawing Inferences
- Code Access

Training-

In order to start training the model, one needs to start the compute instance and push the red power button. The power button will go green and the training instance using the remote GPU will start. The dashboard shows the progress while training, accuracy changes, and completion of epochs. Training will stop if there is any error in the run. If everything is correct, training will stop after the stopping criteria.

2.1.3 The Problem that has been Identified-

- Usage Limitation- There may be many skin cancer detection systems but most of them fail to further classify the type of skin cancer thereby limiting its usage.

- Training barrier- The training of AI systems presents an even larger barrier. Hundreds of thousands of photos that have been confirmed as benign or malignant are used to teach the technology to recognize skin cancer, but all of these images were captured in optimal conditions.

- Technology barrier- Unlike AI technology, board-certified dermatologists don't just look at one mole to determine whether it's problematic. They consider several additional factors, including the other spots on the patient's body and the evolution of the lesion in question, as well as the individual's skin type, skin cancer history and risk factors, and sun protection habits.

2.2 Research Gaps-

- Our project is just a prototype as to what original hardware is. So, the camera used by us i.e., Raspberry Pi 5MP camera is a normal camera and it can only focus up to a certain extent and is not that well suited. So, using a high-power endoscope camera acquired from Amazon for about USD 30, the team captured high resolution images of moles and skin lesions to compare with the images in the growing database.

- There's a huge problem in getting Al data for medicine, but amazing results are possible. The more people share, the more accurate the system becomes. Having a limited data set is the only problem that is present while training the model, if the data set is easily and widely available the accuracy can improve even further. Due to this the model at time may even fail to predict the correct result.

- Availability of camera at proper height and place. Placing the camera each and every time at the accurate position for getting perfect image is itself a task, there is always a chance of human error in such cases thereby affecting the desired output.

2.3 Problem Definition and Scope-

Skin cancer is seen as one of the most hazardous form of cancers found in humans. Skin cancer is the abnormal growth of skin cells. It's a common cancer that can form on any part of the body, but it often occurs on sun-exposed skin. Existing solutions such as image preprocessing which includes hair removal, de-noise, sharpening, resize of the given skin image, segmentation- which is used for segmenting out the region of interest from the given image. Some commonly used segmentation algorithms are k-means, threshold in histogram etc., features extraction from the segmented image and classification of the image from the features set extracted from segmented image. Different classification algorithms can be used for this purpose. The recent skin cancer detection technology uses machine learning and deep learning-based algorithms for classification. The most commonly used classification algorithms are support vector machine (SVM), feed forward artificial neural network, deep convolutional neural network.

These methods to exist but we need something that can detect cancer at a very early stage so that it is easily curable, therefore it is necessary to establish a system such as skin cancer AI detection system. The building block of Skin Cancer AI detector is deep learning which is used to process an image, then recognize it and show the output accordingly. TensorFlow and Keras are used to build and create a machine learning model. Using Convolutional Neural Networks, we developed algorithms and models to distinguish between benign and malignant skin cancers. On detection of a mole as cancerous we can even further identify which type of cancer is there. Which are as follows nevus, melanoma, and seborrheic keratosis. If we can detect the type of cancer, it will be a great added advantage as patients can be made aware at a very early stage.

2.4 Requirements Specification-

The goal of this requirement specification document is to describe the necessary constraints and requirements for the fire detection using image processing.

2.4.1 Introduction-

This section documents the specific requirements (functional and non- functional), performance requirements, design constraints and external interface requirements.

2.4.1.1 Purpose-

The goal of this paper is to provide a full description of how we are making our project, the features and requirements that will be utilized in our 'Skin Cancer AI Detection System,' as well as how it should work. It describes the system's goal and characteristics, as well as what it will perform, the limitations it must work under, and how it will react to external stimuli. This paper is intended for both stakeholders and developers of the system.

2.4.1.2 Intended Audience and Reading Suggestions-

This project is a prototype of Skin Cancer AI detection system using image processing and it is targeting all those who develop moles and want to be sure at a very early stage that whether the grown moles are cancerous in nature or not, so that they can be sure about what treatment they need before consulting a specialist. This has been implemented under the guidance of our mentors.

2.4.1.3 Project Scope-

The building block of Skin Cancer AI detector is deep learning which is used to process an image, then recognize it and show the output accordingly. Using Convolutional Neural Networks, we developed algorithms and models to distinguish between benign and malignant skin cancers. On detection of a mole as cancerous we can even further identify which type of cancer is there. Which are as follows nevus, melanoma, and seborrheic keratosis. If we can detect the type of cancer, it will be a great added advantage as patients can be made aware at a very early stage.

2.4.2 Overall Description-

The description about the project is mentioned below under different sections. The section mainly explains the Product perspective and Product features.

2.4.2.1 Product Perspective-

Our aim is to build a Skin Cancer AI detection system using image processing to get greater accuracy than the ones already existing. The system will notify the supervisor/user by sending him/her a notification on the display screen. The User Interface is worked by writing a line of code which should be accurate to get the output.

The building block of this detector is deep learning which is used to process an image, then recognize it and show the output accordingly. The hardware implementation is done using Raspberry Pi Model 3B+, Intel® Movidius™ Neural Compute Stick, SD card, Camera, USB cables etc. The picture will be received by the camera, and processing will be done inside the Raspberry Pi Model 3B+ & the Intel® Movidius™ Neural Compute Stick will do the heavy lifting and the output will be displayed on the monitor. The goal is to build a machine learning algorithm that can detect cancer images and pair it with mentioned hardware.

2.4.3 External Interface Requirements-

The section explains about the interface requirements under the project. Some light is thrown on the user, hardware and software interfaces.

2.4.3.1 User Interface-

- The skin cancer AI detection system is simple to understand and use, making it user friendly.
- The User Interface is worked by writing a line of code which should be accurate to get the output.
- The user can see the result at the output screen.

2.4.3.2 Hardware Interfaces-

- The hardware part of our system consists of Raspberry-pi, camera module, Intel® Movidius™ Neural Compute Stick and a keyboard.

- The user can interact with the hardware directly as they have to write some line of code before viewing the final result on the output display.

2.4.4 Other Non-Functional Requirements-

Non-functional requirements are important as all the requirements are considered below in this section. Basic Non- functional requirements are:

- Performance of the model should be good enough inrecognizing skin cancer images.
- Response time of the model should be fast
- Model should be robust to any ambiguities
- Model should be reliable in terms of power failure etc.

2.4.4.1 Performance Requirements-

Performance of the system highly depends on the Skin cancer AI detection algorithm.It also depends on the efficiency of the devices used in the system. Resolution of the camera must be high and it should be at appropriate distance to capture clear pictures of skin moles data sample. We need to ensure that every device is in perfect condition and helps in accurate & fast detection.

2.5 Approved Objectives-

- To study existing skin cancer detection devices and techniques.
- To develop a skin cancer AI detection system with good accuracy using image analysis.
- Testing and validating results by comparing with the existing data set.
- Optimized the accuracy with the help of proposed ML model.

2.6 Project Outcomes and deliverables-

- Our project will detect the type of moles whether it is malignant (cancerous) or benign (non-cancerous) using raspberry Pi and neural compute stick.
- The device fabricated would be a one-time purchase.
- Saving life by detecting even smallest of cancerous moles (early detection survival rate of skin cancer is 98 percent).
- Project is practically applicable.
- Project can be extended by upgrading the model to describe which types of cancer it is and how it can be treated.

2.7 Cost Analysis-

In order for the product to work properly the hardware needs to be good and reliable. Proper camera is necessary in order to capture the smallest of moles whose results will be shown on screen, handled by the supervisor. The hardware cost is explained in below table.

Table 2.1

Hardware Required	**Cost (in Rupees)**
Raspberry Pi Model 3B+	3500
Raspberry Pi 5MP Camera	380
Intel® Movidius™ Neural Compute Stick	18000
Keyboard	500
Total Cost	**22380**

2.8 Risk Analysis-

There are always some chances of risk while designing a new hardware system.The below table give the detail analysis of risks that can be faced.

Table 2.2

RISK	MITIGATION STRATEGY
Raspberry-pi hardware canfail	Buy good quality product
Camera can't capture fardistance images	Use high range lens in a camera
Intel® Movidius™ Neural Compute Stick may not be able to process accurately	Buy good quality product

3) FLOW CHART-

3.1 System Architecture-

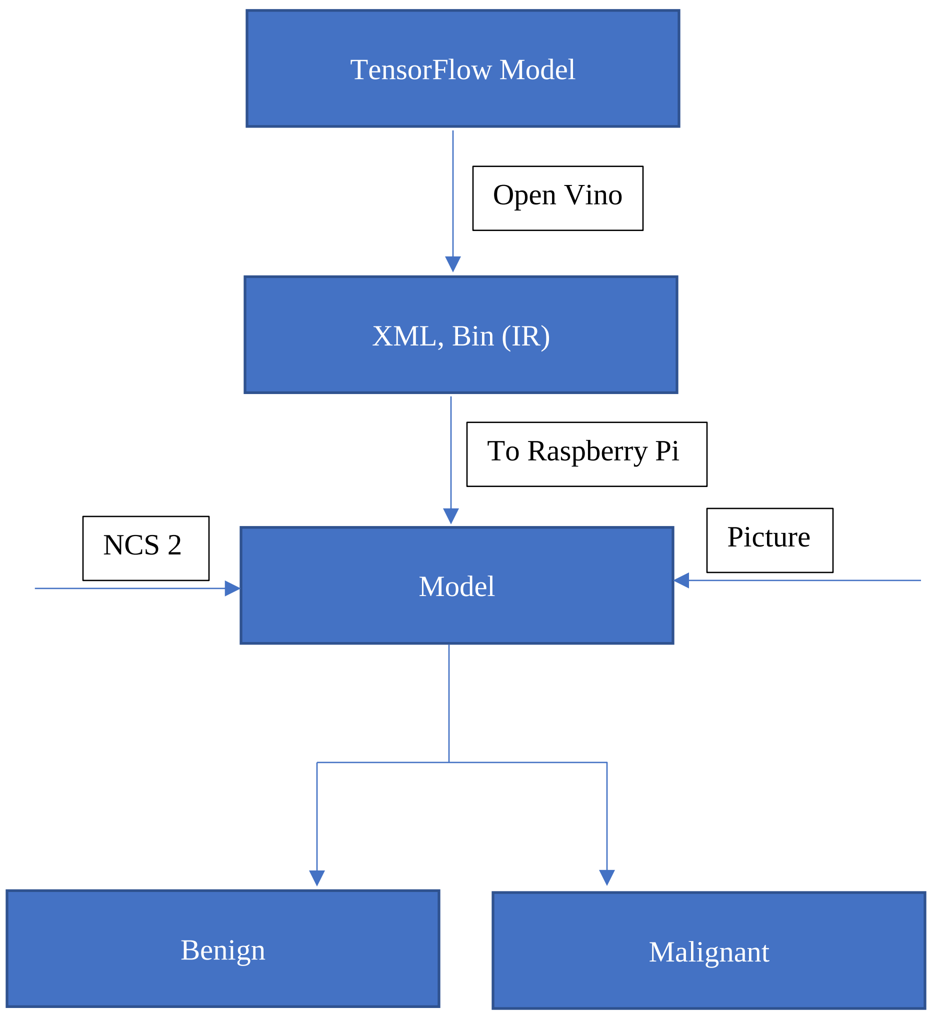


Figure 3.1- System Architecture

3.2 Tools and Technologies Used-

The Project is divided into the following modules-

1. **Hardware-**

- Raspberry Pi 3B+- The Raspberry Pi is a low cost, credit-card sized computer that plugs into a computer monitor or TV, and uses a standard keyboard and mouse.

- Camera Module- It is used to capture clear and accurate pictures of the given skin sample.

- Neural Compute Stick- Intel Neural Compute Stick 2 is powered by the Intel Movidius X VPU to deliver industry leading performance, wattage, and power. The neural compute supports Open VINO, a toolkit that accelerates solution development and streamlines deployment.

2. **Machine Learning Models-**

- Image pre-processing- CNN

- Feature extraction and image pre-process- Mobile Net

- Tools and Technology- Python, TensorFlow, Keras, Open VINO

- Model evaluation and visualization- Weights and Bx`iases (WandB)

- Dataset- Skin Cancer: Malignant vs Benign (Kaggle)

4) PROJECT DESIGN AND DESCRIPTION-

4.1 Description-

In recent days, skin cancer is seen as one of the most Hazardous form of Cancers found in humans. Skin cancer is found in various types such as Melanoma, Basal and Squamous cell Carcinoma among which Melanoma is the most unpredictable. The detection of Melanoma cancer in the early stage can be helpful to cure it. Computer vision can play important role in Medical Image Diagnosis and it has been proved by many existing systems. TensorFlow and Keras are used to build and create a machine learning model. Using Convolutional Neural Networks, we developed algorithms and models to distinguish between benign and malignant skin cancers.

4.2 UG Subjects-

- Machine Learning: Machine learning is the scientific study of algorithms and statistical models that computer systems use to perform a specific task without using explicit instructions, relying on patterns and inference instead.

- UEC513: Embedded Systems- An embedded system is a computer system—a combination of a computer processor, computer memory, and input/output peripheral devices—that has a dedicated function within a larger mechanical or electronic system. Embedded systems tell us about Wires and Ports, Basic Protocols of data transfer, Bus arbitration, ISA bus signals, and handshaking, Memory mapped I/O and simple I/O, Parallel I/O and Port Based I/O.

- UEC610: Computer Architecture- Computer Architecture helps us to Evaluate the performance of a RISC based machine with an enhancement applied and make a decision about the applicability of that respective enhancement as a design engineer (performance metrics). Display an understanding of the concept of pipelining and parallelism pipelining in a modern RISC processor and describe how hazards are resolved.

- UEC620: Deep Learning for Computer Vision- The automatic analysis and understanding of images and videos, a field called Computer Vision, occupies significant importance in applications including security, healthcare, entertainment, mobility, etc. The recent success of deep learning methods has revolutionized the field of computer vision, making new developments increasingly closer to deployment that benefits end users

4.3 Standards Used-

- IEEE 29148 is software requirements specification in a software system to be developed. specifies the required processes implemented in the engineering activities that result in requirements for systems and software products (including services) throughout the life cycle.

- IEEE 1012 is a standard for software project management, software testing, and software engineering, verification and validation.

- IEEE 16326 is standard for Software project management which is an art and science of planning and leading software projects. It provides detailed discussion and advice on applying a set of technical management processes that are common to both the system and software life cycles.

- IEEE 24748 is standard for Software documentation which is written text or illustration that accompanies computer software or is embedded in the source code. It also addresses systems concepts and life cycle concepts, models, stages, processes, process application, key points of view, adaptation and use in various domains and by various disciplines.

4.4 Survey of Tools and Technologies-

The Project is divided into the following modules-

4.4.1 Raspberry Pi 3B+-

The Raspberry Pi is a low cost, credit-card sized computer that plugs into a computer monitor or TV, and uses a standard keyboard and mouse. 1.4GHz 64-bit quad-core processor, dual band wireless LAN, Bluetooth 4.2/BLE, faster Ethernet, and Power-over-Ethernet support (with separate PoE HAT).

4.4.1.1 Working Principle-

- It is a tiny computer board that comes with CPU, GPU, USB ports, I/O pins, Wi-Fi, Bluetooth, USB and network boot and is capable of doing some functions like a regular computer.

- The SoC (system on chip) combines both CPU and GPU on a single package and turns out to be faster than Pi 2 and Pi 3 models.

- The dual-band Wi-Fi 802.11ac runs at 2.4GHz and 5GHz provides a better range in wireless challenging environments and Bluetooth 4.2 is available with BLE support.

- Four pin header is added on the board that resides near 40 pin headers. This allows the Power over Ethernet (PoE) i.e., provides the necessary electrical current to the device using data cables instead of power cords. It is very useful and reduces the number of cables required for the installation of a device in the relevant project.

- PoE works only in the presence of PoE hat.

4.4.1.2 Specification-

- Broadcom BCM2837B0, Cortex-A53 (ARMv8) 64-bit SoC @ 1.4GHz
- 1GB LPDDR2 SDRAM
- 2.4GHz and 5GHz IEEE 802.11.b/g/n/ac wireless LAN, Bluetooth 4.2, BLE
- Gigabit Ethernet over USB 2.0 (maximum throughput 300 Mbps)
- Extended 40-pin GPIO header
- Full-size HDMI
- USB 2.0 ports
- CSI camera port for connecting a Raspberry Pi camera
- DSI display port for connecting a Raspberry Pi touchscreen display

- 4-pole stereo output and composite video port
- Micro SD port for loading your operating system and storing data
- 5V/2.5A DC power input
- Power-over-Ethernet (PoE) support (requires separate PoE HAT)

4.4.2 Neural Compute Stick-

It is a tiny, fanless, deep learning device allows you to learn AI programming at the edge. It is powered by the same high-performance Intel Movidius Vision Processing Unit (VPU) that can be found in millions of smart security cameras, gesture-controlled drones, industrial machine vision equipment, and more.

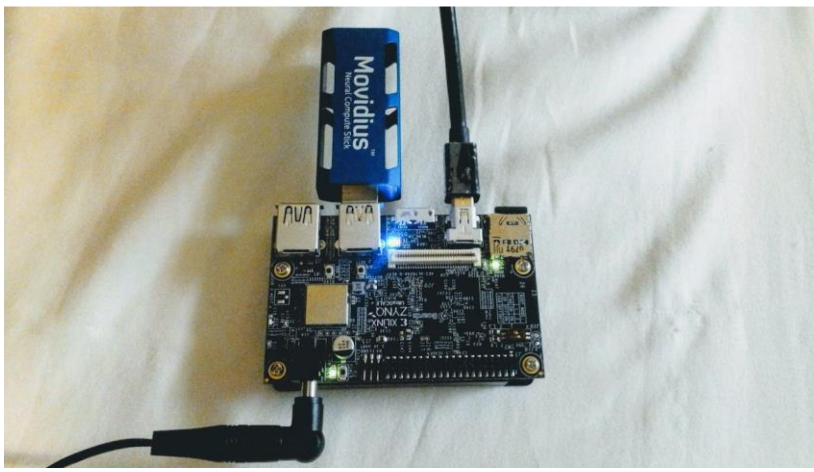


Figure 4.1- Movidius Neural Compute Stick

4.4.2.1 Working Principle-

The Movidius™ Neural Compute Stick (NCS) is a tiny fanless deep learning device that you can use to learn AI programming at the edge. NCS is powered by the same low power high-performance Movidius™ Vision Processing Unit (VPU) that can be found in millions of smart security cameras, gesture-controlled drones, industrial machine vision equipment, and more. The Movidius Neural Compute Stick enables rapid prototyping, validation and deployment of Deep Neural Network (DNN) inference applications at the edge. Its low-power VPU architecture enables an entirely new segment of AI applications that aren't reliant on a connection to the cloud. The NCS combined with Movidius™ Neural Compute SDK allows deep learning developers to profile, tune, and deploy Convolutional Neural Network (CNN) on low-power applications that require real-time inferencing.

4.4.2.2 Specifications-

Table 4.1

Brand	Intel
Form Factor	Stick
Item Height	2.85 Inches
Item Width	0.55 Inches
Standing screen display size	9 Inches
Product Dimensions	2.69 x 1.4 x 7.24 cm; 18.14 Grams
Item model number	NCSM2485.DK
Processor Brand	Intel
Processor Count	1
Hard Drive Interface	USB
Graphics Coprocessor	Integrated Graphics
Graphics Chipset Brand	Intel
Are Batteries Included	No

Item Weight	18.1 g

4.4.3 TensorFlow-

TensorFlow is an open-source end-to-end platform for creating Machine Learning applications. It is a symbolic math library that uses dataflow and differentiable programming to perform various tasks focused on training and inference of deep neural networks. It allows developers to create machine learning applications using various tools, libraries, and community resources. Currently, the most famous deep learning library in the world is Google's TensorFlow.

4.4.3.1 Working-

TensorFlow allows developers to create dataflow graphs—structures that describe how data moves through a graph, or a series of processing nodes. Each node in the graph represents a mathematical operation, and each connection or edge between nodes is a multidimensional data array, or tensor. TensorFlow applications can be run on most any target that's convenient: a local machine, a cluster in the cloud, iOS and Android devices, CPUs or GPUs.

4.4.3.2 TensorFlow Architecture-

TensorFlow architecture works in three parts:

- Preprocessing the data
- Build the model
- Train and estimate the model

It is called TensorFlow because it takes input as a multi-dimensional array, also known as tensors. You can construct a sort of flowchart of operations (called a Graph) that you want to perform on that input. The input goes in at one end, and then it flows through this system of multiple operations and comes out the other end as output.

4.4.4 Keras-

Keras is a deep learning API written in Python, running on top of the machine learning platform TensorFlow. It was developed with a focus on enabling fast experimentation.

Keras is:

- Simple -- but not simplistic. Keras reduces developer cognitive load to free you to focus on the parts of the problem that really matter.
- Flexible -- Keras adopts the principle of progressive disclosure of complexity: simple workflows should be quick and easy, while arbitrarily advanced workflows should be possible via a clear path that builds upon what you've already learned.
- Powerful -- Keras provides industry-strength performance and scalability: it is used by organizations and companies including NASA, YouTube, or Waymo

4.4.4.1 Description-

Keras contains numerous implementations of commonly used neural-network building blocks such as layers, objectives, activation functions, optimizers, and a host of tools to make working with image and text data easier to simplify the coding necessary for writing deep neural network code. The code is hosted on GitHub, and community support forums include the GitHub issues page, and a Slack channel.
In addition to standard neural networks, Keras has support for convolutional and recurrent neural networks. It supports other common utility layers like dropout, batch normalization, and pooling.

4.4.5 Open Vino-

Open VINO™ toolkit is a comprehensive toolkit for quickly developing applications and solutions that solve a variety of tasks including emulation of human vision, automatic speech recognition, natural language processing, recommendation systems, and many others. Based on latest generations of artificial neural networks, including Convolutional Neural Networks (CNNs), recurrent and attention-based networks, the toolkit extends computer vision and non-vision workloads across Intel® hardware, maximizing performance. It accelerates applications with high-performance, AI and deep learning inference deployed from edge to cloud.

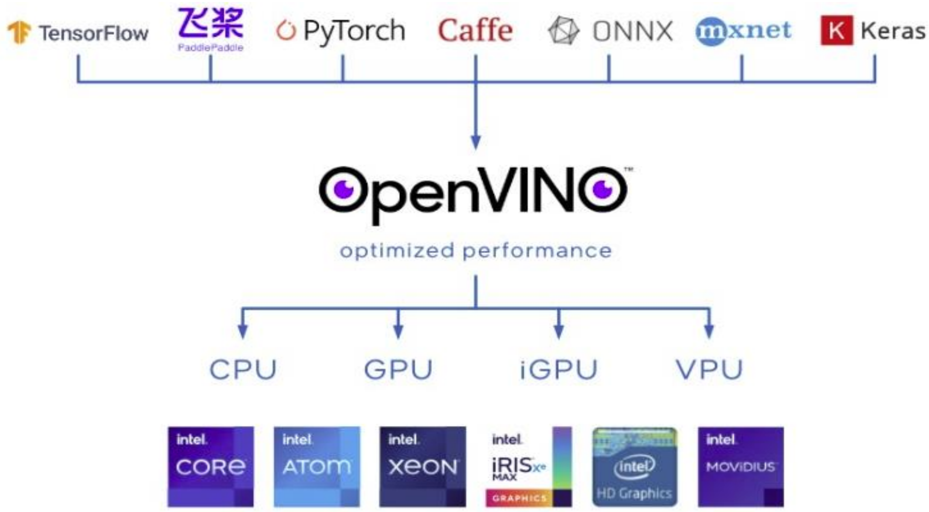


Figure 4.2- Frameworks

4.4.5.1 Description-

Easy Deployment of Model Server at Scale- A complete Open VINO Model Server deployment in Kubernetes and OpenShift can be managed via Model Server resources.

Support for Multiple Model Storage Options- Model repository can be stored in S3-compatible cloud storage like Amazon S3, Azure Blob and Google Cloud Storage (GSC). It is possible to deploy models hosted in local storage on the Kubernetes Nodes or in Kubernetes Persistent Volumes.

Configurable Resource Restrictions and Security Context- It is possible to define OpenShift resource requirements in the model server pods. That include also the usage of AI accelerators like iGPU or VPU. Security context can be tuned to adjust permissions in the model repository.

4.4.6 CNN-

Convolutional neural network is a class of deep, feed-forward artificial neural networks, most commonly applied to analyzing visual imagery because it is designed to emulate behavior of biological behaviors on animal visual cortex. It consists of convolutional layers and pooling layers so that the network can encode image properties.

4.4.6.1 Description-

The convolutional layer's parameters consist of a set of learnable filters (or kernels) that have a small receptive field. This way the image can convolve across spatially, and computing dot products between the entries of the filter and the input and producing a 2-dimensional activation map of that filter. This way the network learns filters that can activate when it detects special features on the input image's spatial feature.

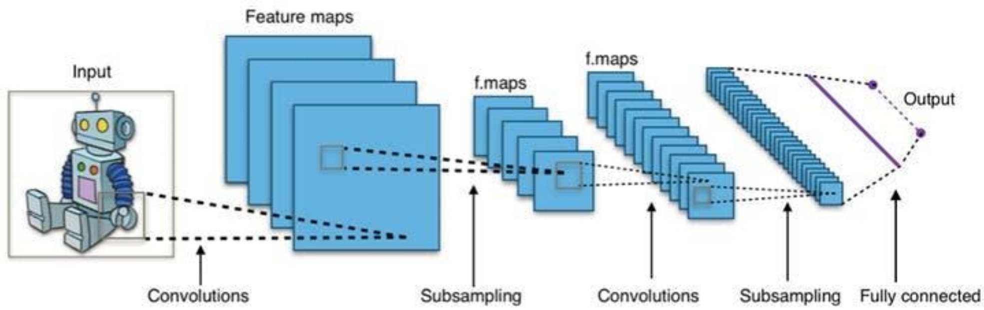


Figure 4.3-Typical CNN network

The pooling layer is a form of non-linear down-sampling. It partitions the input image into a set of non-overlapping rectangles and, for each such sub-region, outputs the maximum. The idea is to continuously reduce the spatial size of the input representation to reduce the number of parameters and computation in the network, so it can also control overfitting. Max pooling is the most common type non-linear pooling.

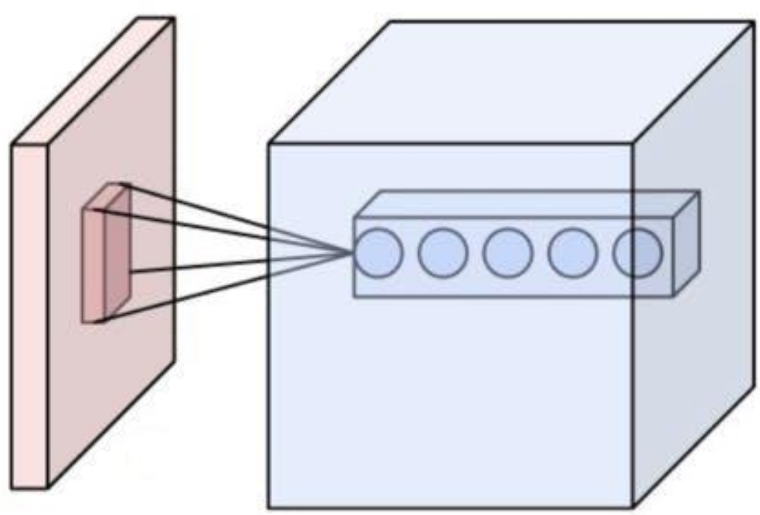


Figure 4.4- Neurons of a Convolution layer (Blue), connected to their receptive (Red)

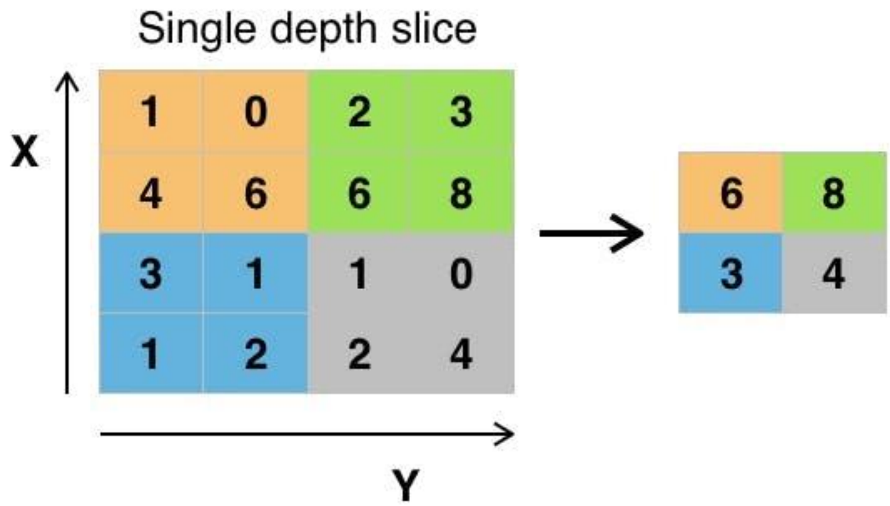


Figure 4.5- Max Pooling

5) GANTT CHART-

Table 5.1

Task	Jan-22	Feb-22	Mar-22	Apr-22	May-22	Jun-22	Jul-22
Capstone Team Formation							
Mentor Selection							
Brainstorming and Idea Selection							
Research and Literature Survey							
Tensorflow model creation							
Openvino configuration on ubuntu							
Openvino configuration on raspbian os							
Ir generation using openvino model optimizer							

NOTE: Which of the following students' outcomes you have achieved till the end of present semester (please answer Yes/No).	
For Capstone project the students of undergraduate program in Electronics and Communication Engineering/Electronics and Computer Engineering will have	
C. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.	
	Yes/No
C1. Analyze needs to produce problem definition for electronics and communication systems.	Yes
C2. Carries out design process to satisfy project requirement for electronics and communication systems	Yes
C3. Can work within realistic constraints in realizing systems.	Yes
C4. Can build prototypes that meet design specifications.	Yes
D. an ability to function on multidisciplinary teams.	
D1. Shares responsibility and information schedule with others in team	Yes
D2. Participates in the development and selection of ideas.	Yes
G. an ability to communicate effectively.	
G1. Produce a variety of documents such as laboratory or project reports using appropriate formats and grammar with discipline specific conventions including citations.	Yes
G2. Deliver well organized, logical oral presentation, including good explanations when questioned.	Yes

H. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.	
H1. Aware of societal and global changes that engineering innovations may cause.	Yes
H2. Examines economics tradeoffs in engineering systems.	Yes
H3. Evaluates engineering solutions that consider environmental factors.	Yes
I. a recognition of the need for, and an ability to engage in life-long learning.	
I1. Able to use resources to learn new devices and systems, not taught in class.	Yes
I2. Ability to list sources for continuing education opportunities.	Yes
I3. Recognizes the need to accept personal responsibility for learning and of the importance of lifelong learning.	Yes
K. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.	
K1. Able to operate engineering equipment	Yes
K2. Able to program engineering devices.	Yes
K3. Able to use electronic devices, circuits and systems modeling software for engineering applications	Yes
K4. Able to analyze engineering problems using software tools	Yes

The learning outcomes for Capstone project are following. Please rate in accordance to your learnings from capstone.

Course Learning Outcomes	Rate between 1-5 (5: achieved, 1: not achieved)
Developing new/multidisciplinary technical skills.	4
Using professional and technical terminology appropriately.	4
Effectively utilizing and troubleshooting a tool for development of a technical solution.	3
Analyzing or visualizing data to create information.	5
Creating technical report with usage of international standards.	4
Acquiring and evaluating information.	5

REFERENCES

- https://www.intel.com/content/www/us/en/developer/articles/technical/doctor-hazel-a-real-time-ai-device-for-skin-cancer-detection.html
- https://www.kaggle.com/fanconic/skin-cancer-malignant-vs-benign
- https://handtoolsforfun.com/how-to-install-opencv-in-a-raspberry-pi-3-b/
- https://www.intel.com/content/www/us/en/support/articles/000055228/boards-and-kits.html
- https://www.intel.com/content/www/us/en/developer/tools/neural-compute-stick/overview.html
- https://reader.elsevier.com/reader/sd/pii/S2352914819302047?token=4154FB73159DF47776D1B0A7E4BBADEAE42AAE3C3B8BA44ADCD5FBAF1BAE3538349B628EA20557C63D0D43E0BC799B7B&originRegion=eu-west-1&originCreation=20220426173026
- https://docs.openvino.ai/latest/openvino_docs_install_guides_installing_openvino_raspbian.html
- https://en.wikipedia.org/wiki/Software_requirements_specification
- https://en.wikipedia.org/wiki/Software_verification_and_validation
- https://en.wikipedia.org/wiki/Software_project_management
- https://en.wikipedia.org/wiki/Software_user_documentation