ASSIGNMENT 1

COMPUTER HARDWARE / SOFTWARE

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MACHINE LEARNING

Machine learning is the science of getting computers to act without being explicitly programmed. In the past decade, machine learning has given us self-driving cars, practical speech recognition, effective web search, and a vastly improved understanding of the human genome.
Machine learning allows software applications to improve their prediction accuracy without being expressly designed to do so. In order to forecast new output values, machine learning algorithms use historical data as input.

TINY MACHINE LEARNING

Tiny machine learning is broadly defined as a field of machine learning which focuses on hardware, algorithms and software capable of performing on-device sensor data analytics at extremely low power.
It enables low-latency, low power and low bandwidth model inference at edge devices, meaning data collected at end devices is not sent to cloud servers for inference.
Latency is another topic of interest in TinyML, since the model runs on the edge, the data doesn't have to be sent to a server to run inference.

ADVANTAGES OF TINY ML

Low Latency
TinyML models runs on edge devices and thus, the data is not sent to any server for inference. This reduces the latency of the output.
Low Power Consumption
Microcontrollers consume very little power. This allows them to function without being charged for long periods of time.
Low Bandwidth
Since data is not sent to a server constantly, less internet bandwidth is used.
Privacy
Since the model is runs on edge devices, and no data is sent to a server, no data is stored in any servers.

COMPONENTS OF TINY ML

TinyML requires a software framework that supports low computational capability and low power hardware infrastructure. Currently only drawing conclusions is supported by TinyML. Therefore, a model is first trained and loaded on to the microcontroller bringing into the memory is the task of the framework. This model is then used to draw conclusions about the problem it is trying to solve.

LAYERS OF TINY ML

Models written in tensorflow can be loaded onto microcontrollers. The models comprise of various layers, which perform different functions on the data, while training. The layers can be arranged in an array, and they work in a sequential manner.
Various layers in a machine learning model are Input Layer, Learnable Layer, Activation Layer , Dropout Layer etc.
To load a tensorflow model, it has to be converted into tensorflow lite using their API. It converts the model to a FlatBuffer, which can be accessed by the microcontroller thereby reducing the model size and modifying it.

APPLICATIONS

1. INDUSTRIES

- Due to the extremely low power requirements of tiny ML devices, it provides a power efficient and low cost solution in various industrial settings.
- TinyML, when used on low-powered devices, can detect faults in a machine ahead of time constantly. It implies maintenance based on predictions, providing an effective and automated product management process which allows lesser faults and more longevity.
- TinyML can be used to monitor equipment in real-time and send out alerts when preventive app maintenance is necessary. This would help reduce downtime owing to equipment failure.
- It has also been useful at remote mining fields for monitoring industrial pumps, as it detects anomalous noises and flags issues before they become serious

2. AGRICULTURE

- Farming has many applications which could utilise tiny ML which range from automatic irrigation, pest detection, crop classifications, smart animal collars, tags for equipment and assets, to name a few.
- Using machine learning-based surveillance systems to monitor every crop field's real-time video feeds identifies animal or human breaches, sending an alert immediately. The use of devices to automatically classify different types of intrusions prove beneficial for the overall health of crops and farmer assets
- With smart embedded systems, it's now possible to combine in-ground sensor data of moisture, fertilizer and natural nutrient levels to analyze growth patterns for each crop over time. Machine learning is the perfect technology to combine massive data sets and provide constraint-based advice for optimizing crop yields.
- Understanding how every type of livestock reacts to diet and boarding conditions is invaluable in understanding how they can be best treated for the long-term. This can be monitored using systems to provide a greater level of insights to the farmers

3. HEALTHCARE

- Healthcare has immense potential to utilize tinyML in x-ray and MRI analysis, smart vital monitoring systems, and many other applications.
- TinyML can be used to monitor critical as well as palliative care patients in real-time, sending out alerts when emergency action is required.

- Recently a device was developed for pneumonia detection in patients with tinyML, using the Edge Impulse platform to detect the disease from chest X-rays. The model can be deployed on single board development platforms like Raspberry Pi 4, and the tiny setup can detect pneumonia in under a minute. This speeds up the detection time from the average 1- 4 days and had 80% accuracy of classification
- Biosensors can also be used for constant monitoring and analysing the data of the daily activities of a patient. This allows better tracking of the activities of a patient and providing alerts on the fly, if the routines followed by the person are not what are required

4. TRANSPORT

- If we apply TinyML to sensors ingesting real-time traffic data, we can use them to route traffic more effectively and reduce response times for emergency vehicles.
- TinyML devices can be used in automatically sensing the pollution levels of a particular vehicle and thus sending an alert to the users. This helps in the reduction of pollution due to emissions.
- Sensors embedded in vehicles and traffic cameras may automatically register accidents and automatically send alerts to the emergency services in the case of any incident
- Automatic traffic scheduling can improve the efficiency of the traffic system by decreasing significant delays and easing congestion. Automating the traffic scheduling based on the density of vehicles waiting, without any human intervention has applications in reducing congestion. Presently, the traffic signal timers are preset which is unreasonable for a stochastic process like vehicular traffic. The proposed methodology detects vehicles with piezoelectric sensors embedded across each lane. Further, a TinyML based model predicts the green signal timings to regulate the traffic.