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EMBEDDED SYSTEMS FOR FACE OCCLUSION DETECTION THROUGH DEEP LEARNING TECHNIQUES

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Abstract:
Facial recognition systems are widely employed in many different fields, including security, monitoring, and identity verification. Scarves, masks, and other face occlusions provide a significant challenge to these systems' accuracy and robustness. Determining the type of occlusion is necessary to improve the performance of face recognition systems under blocked conditions. The use of deep learning has gained significant traction and is currently widely used in computer vision systems. There are number of deep learning architectures developed over time to handle different kinds of problems. However, these networks require high-performance computing resources like GPUs and TPUs to operate well, and they consume a lot of energy. This paper addresses the embedded systems for face occlusion detection through deep learning techniques.

Keywords: Embedded system, Face occlusion, Deep learning, Transfer learning

I. INTRODUCTION

One of the major problems concerning facial recognition systems is face occlusion, and face occlusion is homage to the occluding factor on the face, such as glasses, beard, scarf, cap, and more. Most of the embedded devices have limitations and are limited power supply and computing capability. Single Board Computers are becoming more and more common for embedded computer vision systems because of their high processing capability, small size, and low power consumption. Embedding the occlusion detection in the embedded platform will help a lot to design systems for the real world that is of small size and consume less power, such as portable and with fewer resources.

II. LITERATURE SURVEY

This study [1] presents an approach for automatically identifying and recovering the occluded face region. It concentrates on two aspects of the face recovery problem: the identification of occlusion and the superior recovery of the occluded areas. The results show that the method outperforms other algorithms in recovery quality on a constant basis.

This research [2] presents a technique for detecting and recovering the occluded facial region. It is predicated on the knowledge that every face has a combination of symmetric and non-symmetrical facial features, and that each symmetrical feature accentuates the natural contours of the face The proposed technique for identifying and recovering blurry face pictures achieves a high recovery rate of 73%.

This study presents a facial occlusion verification method for automated teller machines (ATMs) [3]. Even in the presence of position fluctuations and face occlusions, the proposed head and shoulder recognition method and the global and local skin color area ratios-based occlusion verifier can reliably extract face areas. Experimental results show that the proposed head and shoulder identification approach has a 94.8% detection rate even when faces are highly obscured.

The Raspberry Pi board was used in [4] to demonstrate an image-capturing technique for an embedded system. They were able to create an embedded image capturing system utilizing the Raspberry Pi platform by considering the requirements of the image capturing and recognition technique, the Raspberry Pi CPU module, and its peripherals.

The authors of research [5] provide a dependable and effective method for precisely identifying facial occlusion utilizing convolutional neural networks and multi-task learning. Accurately predicting the coverage of many facial regions, such as the nose, mouth, and both eyes, is possible using the multitask CNN. They used the FO and the AR face dataset to evaluate the method's efficacy.

The suggested work in [6] is an embedded car security system that recognizes the driver's face and compares it to a preset face image using a Face Detection System (FDS). It consists of a PC memory unit with multiple driver images stored in it. The facial detection subsystem (FDS) recognizes the driver's face and compares it to a preset image. If the picture doesn't match, the owner gets the information through MMS.

The design and implementation of an embedded Linux platform-based face detection ATM security system is the main objective of this work [7]. The process of methodically identifying a person's face provides security. The system's clever feature is that it will notify the user if they try to cover their face so that it can be accurately identified. The projected system uses the Haar cascade feature to extract the face from the image. The CPU of the system is a Raspberry Pi board.

III. HARDWARE FOR EMBEDDED COMPUTER VISION

Single Board Computers (SBCs) are becoming more and more common for embedded computer vision systems because of their high processing capability, small size, and low power consumption. Every single-board computer (SBC) has specific benefits and limitations. Here is a description of some popular Single Board Computers (SBCs) for integrated computer vision applications.

- Raspberry Pi
  The Raspberry Pi Foundation developed the Raspberry Pi 4[8] Model B single-board computer that could be implemented for multiple purposes, including computing education. Due to the 1.5GHz quad-core Cortex-A72 CPU and up to 8GB LPDDR4, it boosts process and allows to use a few windows simultaneously. It is possible to establish physical and wireless networking owing to the various connections, including Bluetooth 5.0, dual-band Wi-Fi, and a gigabit Ethernet. It uses micro-HDMI connectors with dual-display output, which implies that user can plug in more than two screens The Raspberry Pi 4 utilizes several operating systems, such as Ubuntu and Raspberry Pi OS

- NVIDIA Jetson Nano
  Designed to operate multiple neural networks simultaneously, the NVIDIA Jetson Nano [9] is a small and powerful computer that is perfect for AI-centric activities like object identification, audio processing, and image categorization. Because of its low power consumption of up to 5 watts, it is appropriate for edge computing applications. This development board is designed for edge computing applications driven by AI, such as robotics and smart cameras.

- ESP32
  Espressif Systems developed the ESP32 [10] as a versatile, inexpensive single-chip microcontroller system that can be used in many different fields like embedded systems programming, robotics design or home automation technology development etcetera. It supports Bluetooth and Wi-Fi necessary for network connection in Internet of Things applications (IoT). In addition to this there are also other built-in ADCs (Analog-to-Digital Converters), DACs (Digital-to-Analog Converters), UARTs (Universal Asynchronous Receiver Transmitters), SPI (Serial Peripheral Interface) ports and I2C bus interfaces; GPIO pins allow connection with external sensors or actuators.

- BeagleBoard
  In 2008, this computer was created by Texas Instruments called the BeagleBoard-X15 [11]. It is a type of single board computer that can be used by hobbyists and learners who work on open-source software. The processor has a 1.5 GHz dual-core ARM Cortex-A15 engine which is capable of handling complex operations in a computer, 2GB DDR3L RAM and 4GB eMMC storage. For connectivity options, it

provides USB ports, Ethernet, HDMI output and a 3D graphics accelerator is also included so that multimedia operations can be done easily with this device. It supports Linux OS such as Debian-based BeagleBoard OS.

- Leopard Board
  A family of embedded development platforms called Leopard Boards [12] is intended for use in video processing and digital signal processing (DSP) applications. Equipped with Texas Instruments' TMS320DM355 high-performance DSP processor, these boards are perfect for applications like video encoding and decoding. Due to these characteristics, the Leopard Board is perfect for applications that need multimedia functionality and sophisticated video processing in embedded systems.

IV. EMBEDDED SYSTEM DESIGN

The Raspberry Pi was selected as the central processing unit for the embedded system because of its small size, low cost, and adequate processing power for task involving the processing of images in real time. A camera module for taking face images, a Raspberry Pi for processing and occlusion detection, and a display unit for showing the outcomes make up the system design. The developed models was incorporated into an embedded system using a Raspberry Pi for detecting occlusions in real-time. The system design is comprised of:

- Hardware Configuration:
  Assembling the Raspberry Pi with necessary add-ons such the camera module, power supply, external storage, and display components is known as the hardware configuration. To enable software execution, an operating system is installed, usually Raspberry Pi OS. In order to verify appropriate operation, the camera module and display are attached and tested.

- Software Configuration:
  To facilitate the execution of deep learning models and video processing, dependencies such as OpenCV and NumPy are installed on the software side. The Raspberry Pi will be equipped with trained models, such as YOLOv8 Small, YOLOv8 Nano [13], and MobileNetV2 [14]. To communicate with the camera module, record video streams, preprocess frames, and use the learned models to identify occlusions in real time, a unique detection script is written.

Using the integrated models, the detection script is run on the Raspberry Pi to evaluate its performance in scenarios involving real-time occlusion detection.

V. CONCLUSION AND FUTURE SCOPE

Face occlusion, or objects on the face such as glasses, a beard, a scarf, a cap, or other items, is one of the primary issues with facial recognition systems. Embedded devices frequently have constrained computing and power capacities. Developing an occlusion detection system especially for embedded platforms guarantees that performance and efficiency won't suffer when the system is utilized on other platforms. Single Board Computers have an increasing application in embedded computer vision systems due to their low power consumption, small size, and high processing capability. The Raspberry Pi was chosen as the embedded system's central processing unit due to its portability, affordability, and sufficient computing capability for tasks requiring real-time image processing. The system design consists of a camera module for taking face images, a Raspberry Pi for processing and occlusion detection, and a display unit for displaying the results.

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