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Research projects, Transfer of Science or Research

Medical technology: diabetes retinal screening through deep learning

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Diabetic retinopathy (DR), a complication of the retina brought about by diabetes, is one of the most frequent reasons for vision loss in European adults between 25 and 60 years of age. When detected early, treatment can effectively reduce or prevent vision loss. To date however, national screening programs have been available in only a few countries and even then, they are costly.

As part of the FED4SAE innovation measure supported by fortiss, Ubotica Technologies emerged as the winner of an open call and has developed a deep learning-based solution for detecting the presence of DR indicators in retinal images. These DR indicators can be made recognizable with the help of special retina and fundus cameras.

By employing the neural network dependability kit (NNDK) software developed by fortiss, researchers were able to improve the deep learning model so that it can be directly utilized in a fundus camera. The solution was developed to help ophthalmologists consistently and precisely assess and

Motivation

The goal of the development was to create a working prototype that demonstrates the classification of retinal fundus images for the presence of DR indicators. Due to their data-managed approach however, the inherent uncertainties of machine learning algorithms restrict integration into this type of classification system, especially in such a safety-critical application.

The major challenges in employing artificial intelligence-based (AI) solutions involve on the one hand the ability to make statements regarding the reliability of artificial neural network (ANN) decisions with respect to robustness, interpretability and accuracy, and on the other the continuous monitoring of the neural network decisions.

Solution

Neural networks are artificial networks made up of many small units (neurons) featuring a high degree of connectivity. The individual neurons are adaptive, which means the network is able to learn. Neural networks have been utilized on a large scale in recent years in a wide range of applications such as autonomous driving, or in production for image recognition, object detection and perception, and also for decision making. The issue is that these adaptive components are difficult to test with conventional methods. For the ANN-supported classification of medical images in particular, it's important to determine the robustness of ANNs with respect to noisy or even maliciously manipulated sensor data. Since there is no proven method for the development of reliable neural networks, there is also a significant demand for diverse metrics suitable for measuring important reliability characteristics.

Using 35,000 freely-available, pre-classified retinal images, Ubotica trained a deep learning-based neural network for DR indication. The technical solution utilizes the
Intel Movidius Myriad X Vision Processing Unit (VPU), an electronic processor unit that can be directly integrated into the fundus camera. The VPU first pre-processes the retinal images with its integrated image filter functions. The trained neural network is then utilized to screen the retinal image for DR indicators. NNDK is employed in the development of the neural network to assess its performance with various metrics, and thus to further improve the model.

NNDK, a fortiss-developed open source toolbox for supporting safety engineering and a better understanding of neural networks, aids the verification, test case generation and calculation of metrics for neural networks. The platform relies on formal methods for modeling and rigorously testing computer systems in order to verify the accuracy of safety critical systems and to argue for the quality of neural networks. This allows the development of neural networks that are more robust, reliable, interpretable and trustworthy.

tainties in the product life cycle
- runtime monitoring for arguing whether a neural network decision is supported during operation through previous similarities in the training data
In the development of the DR detection system, the NNDK reliability metrics and its support for runtime monitoring played a special role. With the help of a special metric for calculating the neuron coverage, the size of the neural network could be reduced by 74 percent for example - without significantly influencing its accuracy when classifying the retinal images - thus significantly accelerating calculation of the classification results. Furthermore, the runtime monitoring function was employed to show the user of the camera the training images that most closely match the analyzed image. This allows the person examining the images to perform an additional independent review of the decision made by the AI technology, thus supplementing the in-line DR detection with one verifiable AI element.

Value proposition
The solution that was developed is not aimed at replacing medical experts with the screening of the retinal fundus images, rather to support the role of the examining physician through the creation of an initial classification. What's also crucial is that fortiss added an explanation component for medical professionals, which reinforces trust in the decision made by the AI technology. The software thus helps ophthalmologists precisely and consistently assess and diagnose DR.

Ubotica is working together with retina camera manufacturers and the Irish public health service to establish the solution on the market. The function in the NNDK software that monitors the decisions made by the ANNs offers a significant advantage for solution integrators. The utilization of Ubotica's technology will considerably improve the efficiency of the cameras, as well as the ophthalmologist's approach.

Partner
Ubotica Technologies is small-to-medium Irish enterprise that specializes in AI solutions for edge-based computer vision applications. The company maintains development centers at several European locations that collaborate with research centers to spur innovations for the target markets. The primary target markets include aerospace, high-speed motion tracking and medical image analysis.

Ubotica emerged as an open call winner within the framework of the FED4-SAE initiative (Federated Cyber-physical Digital Innovation Hubs for the Smart Anything Everywhere initiative), a program that offers European start-ups and small-to-medium enterprises access to leading technology sources, expertise and industrial platforms, in addition to well-connected business infrastructures and regional innovation centers.