Real-Time Diabetes Retinopathy Monitoring IoT Device with Machine Learning

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Abstract

Diabetic retinopathy (DR) is the leading cause of blindness worldwide. It is estimated that more than 105 million people have been affected. When high blood sugar damages blood vessels in the retina, a layer of light-sensitive cells at the back of the eye, Damaged blood vessels can swell and leak, causing blurred vision or stopping blood flow. Sometimes new blood vessels grow, but they are abnormal and can lead to further vision problems.

This project shows how we can use a tiny device with machine learning capabilities to monitor the retina of a diabetic patient in real-time. We will use two main machine learning algorithms to improve the accuracy of test results.

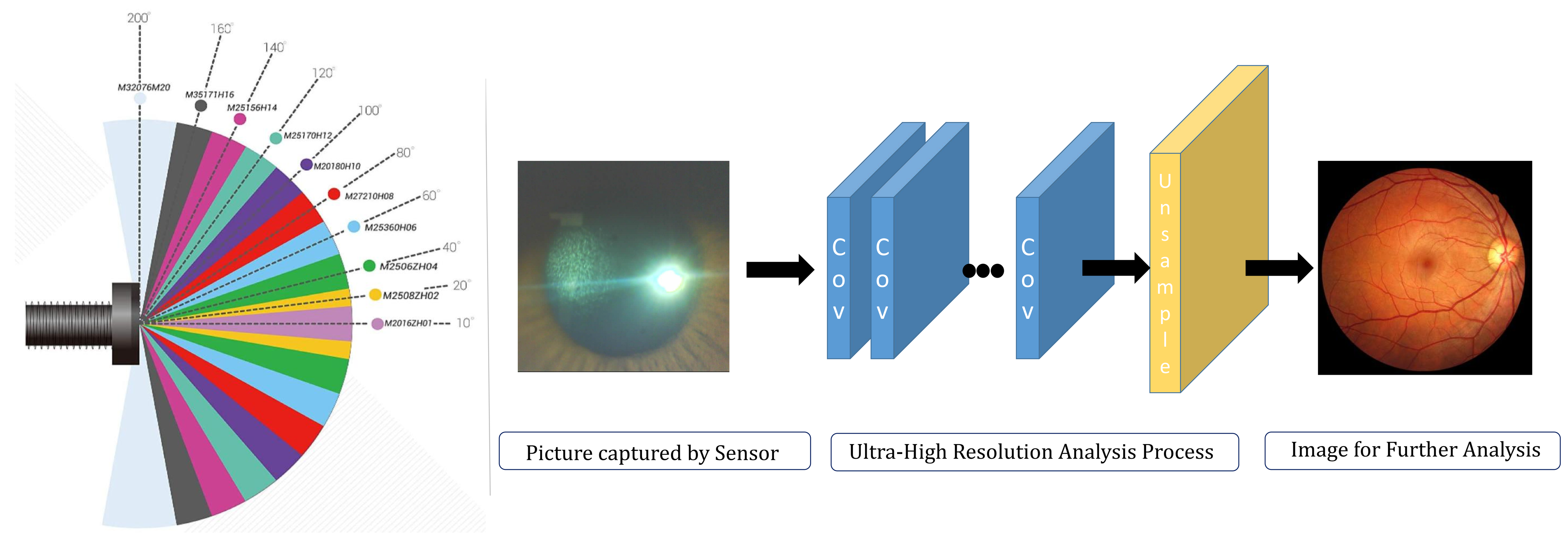
Introduction

1. Diabetic Retinopathy Level:
   1. **Mild**: These patients have at least one microaneurysm(MA) but no other findings. Findings are often subtle, so close inspection and monitoring are essential.
   2. **Moderate**: These patients have hemorrhages or MAs in one to three retinal quadrants and/or cotton wool spots, hard exudates, or venous beading.
   3. **Severe**: These patients have intraretinal hemorrhages (> 20 in each quadrant), venous beading in two or more quadrants, or an IRMA in one or more quadrants. These findings must be in the absence of neovascularization, which would indicate PDR.
   4. **Proliferative DR**: These patients had NPDR that has progressed to PDR, and they exhibit either neovascularization of the disc/elsewhere or vitreous/preretinal hemorrhage.
2. ESP32 Module:
   1. ESP32 can perform as a complete standalone system or as a slave device to a host MCU, reducing communication stack overhead on the main application processor.

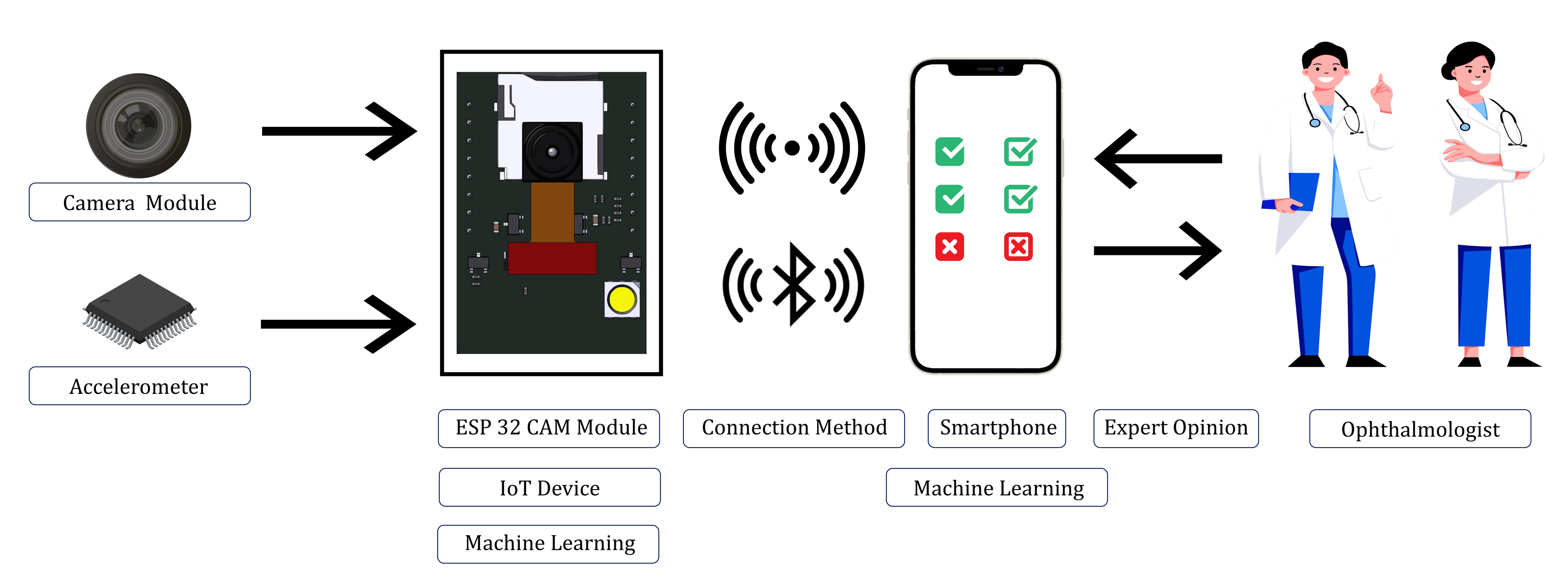
Current Challenges

1. Patients must go to the hospital for a diagnosis of retinal conditions.
2. Existing retinal detection devices are too expensive.
3. Existing retinal detection devices are too bulky.
4. The patient cannot do it by themselves, and the retina must be seen with the help of someone else.

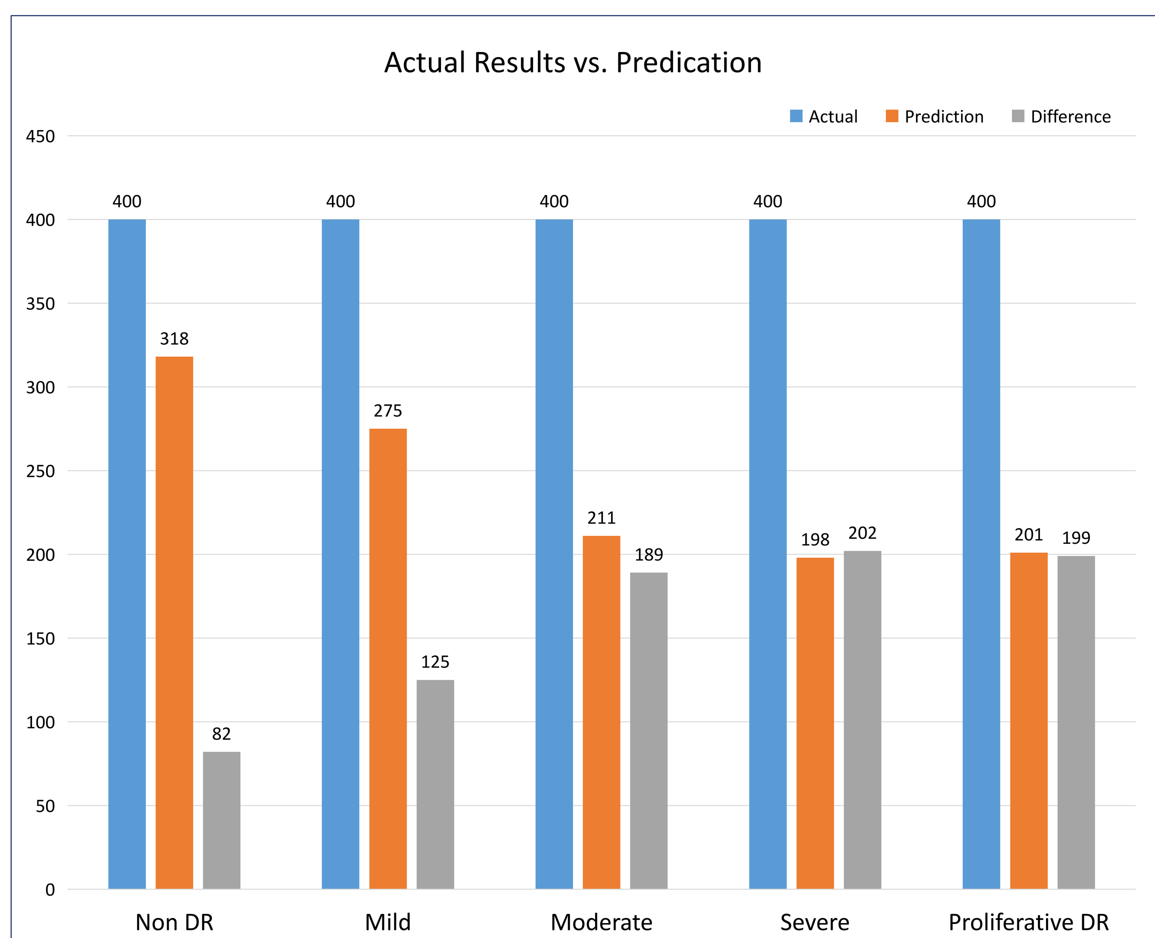
Methodology

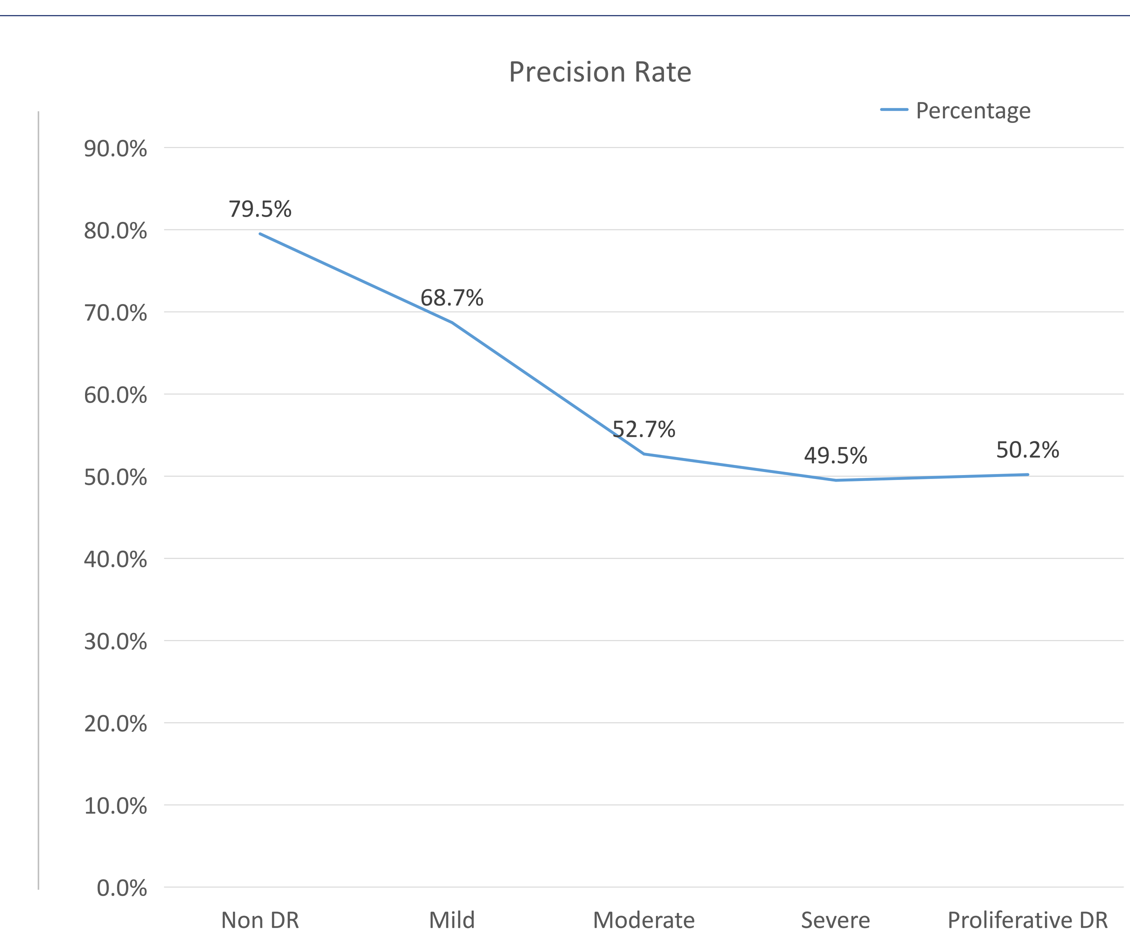


Key Concept



Results





Feture Works

1. Integrate the camera module.
2. Design an Ultra-High Resolution Image Analysis algorithm.
3. Build a platform on mobile phones that connect doctors and patients.
4. Optimize the training algorithm and increase the number of training images.
5. Work with hospitals to get people with diabetes to experience this device to get more actual data.
6. Research other eye diseases and expand the number of beneficiaries through training algorithms.

Conclusions

1. At present, the accuracy of the DR detection algorithm is relatively low due to the lack of training repetition. The accuracy will be significantly improved with the continuous increase of training times.
2. With the gradual increase of diabetes patients worldwide, the number of patients with diabetic retinopathy is also increasing. If optimized devices become commercially available, more people with diabetes could monitor their retinas in real-time and stay in touch with their ophthalmologist, no matter where they are.

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References

1. Sivaprasad, S., Gupta, B., Crosby-Nwaobi, R., & Evans, J. (2012). Prevalence of diabetic retinopathy in various ethnic groups: a worldwide perspective. Survey of ophthalmology, 57(4), 347-370.

2. Lechner, J., O'Leary, O. E., & Stitt, A. W. (2017). The pathology associated with diabetic retinopathy. Vision research, 139, 7-14.