Available online at www.sciencedirect.com

ScienceDirect

Procedia Technology 27 (2017) 14 – 15

Procedia Technology

Biosensors 2016

Magnetic-particle based signal amplification method integrated with mobile-devices for low cost biosensing

Omary Mzava[a], Zehra Taş[a], Vahit Can Lafcı[a], Mehmet Akif Çakar[a], İbrahim Özdür[a], Kutay İçöz[a]*

[a] *Abdullah Gul University, Department of Electrical and Electronics Engineering, Barbaros Mah. Erkilet Blv.,Kocasinan, Kayseri 38080, Turkey*

Abstract

We present a signal amplification method for biosensing applications using magnetic particles. In this method, mobile devices and simple spherical glass beads are used as a low-cost microscope to detect magnetic particles. Magnetic particles have two main functions; 1) conventionally capture, separate and transport target molecules 2) form magnetic dipoles under an applied external magnetic field to attract other magnetized particles. When magnetic particles accumulate and form a cluster, the corresponding pixel area in the image taken by the simple microscope is increased resulting in signal amplification.

Current focus of new generation biosensor research is to increase the sensitivity levels of the devices to compete with current lab analysis tools while inherently having other advantages such as being low-cost, portable and simple. Biosensors based on micro/nano magnetic particles use various measurement techniques and amplification methods. In order to fully benefit from the advantages of micro/nano technology based systems, measurement set up must be also portable and have high sensitivity. Mobile devices and applications are taking place in medical fields and have high potential for future. In this work mobile devices are employed as measurement setups for the magnetic particle based sensing and signal amplification. The amplification method is not based on bimolecular binding thus cost efficient. After the images of the magnetic particles are taken, these images are sent to cloud computing for analysis by the mobile device. Matlab codes run on cloud servers for processing the images. Finally results are received and displayed on the mobile device.

The mobile device based imaging system is able to detect 7 **µ**m size particles within a 1500 **µ**m x1500 **µ**m area and magnetic bead accumulation resulted in at least 5-fold signal amplification. The applied magnetic field is approximately 15 mT and the cost of the system excluding mobile device is under 20 cents. The method is promising for immunomagnetic bead assisted biosensors.

* Corresponding author. Tel.: +90-352-224-8800; fax: +90-352-338-8800.
E-mail address: kutay.icoz@agu.edu.tr

Peer-review under responsibility of the organizing committee of Biosensors 2016
doi:10.1016/j.protcy.2017.04.008

Peer-review under responsibility of the organizing committee of Biosensors 2016

Keywords: magnetic particle accumulation; cellphone microscopy; signal amplification

1. Signal amplification and cell phone based analysis

The method proposed in this method consists of 4 main parts: 1) Immunomagnetic beads for target capture and separation) 2) Uncoated magnetic particles for signal amplification 3) Mobile Device with Spherical Ball Lens for image recording, internet connection and user interface 4) Cloud Computing for running Matlab analysis.

External magnetic field exerts magnetic dipoles on magnetic particles, this magnetic dipole-dipole interaction results in attraction of particles to each other and thus forming accumulation. By changing the parameters of force equations, the size of the accumulation can be controlled. The accumulation can be used as a signal amplification method. Among the various signal amplification methods in biosensing, which heavily depend on biomolecular interactions, magnetic accumulation based signal amplification is simple, cost and time efficient. Since it is not based on biomolecular interactions, it is not pH and temperature sensitive. The magnetic force components due to dipole-dipole interaction depend on magnetic susceptibility and radius of each magnetic particle, distance and angle between particles and applied external magnetic field [1, 2].

In order to measure the size of magnetic particle accumulation, spherical ball lens attached to cellphone camera to form a mobile microscope. This simple system provides approximately 100X magnification and 3.4 μm resolution. The images recorded are sent to cloud servers through the web browser of the mobile device. The user interface allows user to choose which accumulation to be analyzed. On the cloud servers Matlab codes run for image processing. Matlab has many built-in functions for image processing and allows performing various analyses. The interface and cloud computing is shown in Fig.1.

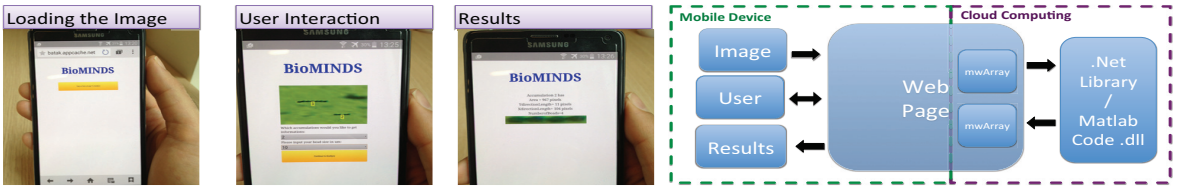

Figure 1: Cell phone microscopy and cloud computing based analysis for accumulation of magnetic particles.

2. Results

To validate the measurements of the cell phone microscopy and cloud computing, same accumulations are also measured using an optical light microscope. The R^2 value for the measurements is 0.96 showing that cell phone microscopy and cloud computing based system is producing reliable results.

Acknowledgements

Authors acknowledge TÜBİTAK (Project No: 114E886) and AGU BAP (2015-11) for financial support. Omary Mzava acknowledges TÜBİTAK for the scholarship (2215).

References

[1] van Kleef R, Myron H, Wyder P, et al. Limits of magnetic flocculation in colloidal dispersions. *IEEE Trans Magn*. 1983;19(5):2118-2120. doi:10.1109/TMAG.1983.1062708.

[2] Lu S, Pugh RJ, Forssberg E. *Interfacial Separation of Particles*.; 2005