Chapter 85
Emerging Technologies Serving Cytopathology: Big Data, the Cloud, and Mobile Computing

Abraham Pouliakis
https://orcid.org/0000-0002-0074-3619
National and Kapodistrian University of Athens, Greece

Niki Margari
https://orcid.org/0000-0003-4975-8616
National and Kapodistrian University of Athens, Greece

Effrosyni Karakitsou
National and Kapodistrian University of Athens, Greece

Stavros Archondakis
https://orcid.org/0000-0001-7491-0953
401 Military Hospital, Greece

Petros Karakitsos
National and Kapodistrian University of Athens, Greece

ABSTRACT

Cytopathology became a popular since George Papanicolaou proposed the famous test Pap 60 years ago. Today cytopathology laboratories use the microscope as primary diagnostic device; however modern laboratories host numerous modalities for molecular tests and exchange data via networks; additionally, there are imaging systems producing pictures and virtual slides at enormous sizes and volume. The latest technological developments for cloud computing, big data and mobile devices has changed the way enterprises, institutions and people use computerized systems. In this chapter are explored potential applications of these technologies in the cytopathology laboratory including: data storage, laboratory information systems, population screening programs, quality control and assurance, education and proficiency testing, e-learning, tele-consultation, primary diagnosis and research. The impact of their adoption on the daily workflow is highlighted, possible shortcomings especially for security and privacy issues are identified and future research directions are presented.

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INTRODUCTION

The term "cloud services" (also known in modern technology jargon as "the cloud") refers to a network of servers connected by the Internet or any other type of network that enables users to combine and use computing power on an as-needed basis. Cloud computing is a novelty that rapidly showed tremendous opportunities for applications in medicine and health care improvement (Eugster, Schmid, Binder, & Schmidberger, 2013; Fernandez-Llatas, Pileggi, Ibanez, Valero, & Sala, 2015; Glaser, 2011; Kuo, 2011; Lupse, Vida, & Stoicu-Tivadar, 2012; Mirza & El-Masri, 2013; Patel, 2012; Rosenthal et al., 2010; Waxer, Ninan, Ma, & Dominguez, 2013). It is expected that by 2018 there will be approximately a 27% increase in the US cloud computing market for medical images at a Compounded Annual Growth Rate (CAGR). This is mainly due to the growing volume of medical images and the increasing costs of ownership for maintaining Picture Archiving and Communication Systems (PACS) (GlobalData, 2012). To deal with this challenge, analysis techniques, especially suitable for the laboratory environment, have been developed for future application (A. Pouliakis, Archondakis, Karakitsou, & Karakitsos, 2014; A. Pouliakis, Spathis, et al., 2014).

In parallel to cloud computing there are new developments for mobile computing. Especially in the health sector Mobile Health (mHealth); which is defined as the practice of medicine and public health supported by mobile devices; is nowadays evolving. Available mHealth applications are nowadays used for collecting community and clinical health data, delivering healthcare information of patient vital signs in real-time, as well as direct healthcare provisioning. Today there are available handheld computing applications for: ambulatory medicine (Banitsas, Perakis, Tachakra, & Koutsouris, 2006; Kiselev, Gridnev, Shvartz, Posnenkova, & Dovgalevsky, 2012; Pavlopoulos, Kyriacou, Berler, Dembeyiotis, & Koutsouris, 1998; Rosales Saurer, Mueller-Gorchs, & Kunze, 2009; Zerth, Besser, & Reichert, 2012), diabetes management (Ribu et al., 2013; Skrovseth, Arsand, Godtliebsen, & Hartvigsen, 2012; Spat et al., 2013), asthma management (Finkelstein, Hripcsak, & Cabrera, 1998; Gupta, Chang, Anyigbo, & Sabharwal, 2011), control of obesity (Patrick et al., 2009), smoke cesation (Ghorai, Akter, Khatun, & Ray, 2014; Ybarra, Holtrop, Prescott, & Strong, 2014), seizure management (Pandher & Bhullar, 2014), stress management (Clarke et al., 2014) and treatment of depression (Burns et al., 2011) among others.

However the majority of mHealth of applications are related to fitness (43%) followed by health resource (15.0%) and diet/caloric intake (14.3%,). User engagement has the form of self-monitoring and training (74.8%) (Sama, Eapen, Weinfurt, Shah, & Schulman, 2014); Despite the fact that do exist applications targeting patients, currently, there are rather limited applications targeting physicians and doctor-patient interactions (Martin, 2012). Pioneering field seems to be radiology consultation for X-rays and mostly Computer Tomography (Choudhri et al., 2013; Johnson et al., 2012; Toomey et al., 2010) and ECG transmission (Vaisanen, Makijarvi, & Silfvast, 2003). mHealth applications are very limited in the fields of pathology and even less in cytopathology; despite both specialties deal with images. In relation to pathology, the most reported uses of handhelds, are limited to experimental endeavors in education and telemedicine (Park, Parwani, Satyanarayanan, & Pantanowitz, 2012). For the field of cytopathology, even after a thorough search, there are found rather limited articles or reports . However, pathology and cytopathology share many common characteristics. Actually, in most countries, cytopathology is considered as a subspecialty of pathology. Thus concepts and ideas can be useful to both specialties; therefore applications can be transferred from one domain to the other.

Within this chapter, we analyze the state of the art related to the application of cloud computing services and infrastructure and mobile computing for cytopathology, identify and propose potential applica-