

CONNECTED, LOW-COST POINT-OF-CARE DIAGNOSTICS FOR RURAL SOUTH AFRICAN CLINICS

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ABSTRACT

In rural settings, the implementation of data connectivity for point-of-care (POC) diagnostics is becoming increasingly important, but introduces complex challenges, where cost, infrastructure, and training of staff need to be balanced if effective solutions are to be realized. Possible solutions for connected POC diagnostics from a South African perspective have been identified, and initial results are presented, utilizing wireless, printable radio-frequency identification (RFID) techniques.

KEYWORDS: Printed sensors, Paper-based sensors, Radio frequency identification, Point-of-care diagnostics

INTRODUCTION

Data connectivity is an imperative consideration in the development of new POC diagnostic devices, particularly in the developing world [1,2]. In addition, the ASSURED criteria [3] set out by the World Health Organization for the development of new POC diagnostic tools need to be taken into consideration. In South African rural clinics, poor quality management systems, supply chain management, and staff competency have been highlighted as major factors hindering the successful implementation of POC diagnostic services [4]. RFID techniques can address these challenges by providing a wireless and contamination-free connectivity solution.

METHODOLOGY

Interviews were conducted at five primary healthcare clinics (PHCs) in resource-limited settings in Northern Gauteng, South Africa, and indicated that POC testing is a largely manual process – from sample introduction to tracing and capturing of results. Figure 1 illustrates the proposed high-level solutions utilizing wireless techniques in the context of typical current South African clinic workflows, compatible with the Health Level Seven (HL7) international electronic healthcare information standards. A low-cost color detector was implemented for use with existing lateral flow devices (LFDs) utilizing an RFID sensing chip (SL900A-DK-STQFN16, ams, Austria), green light-emitting diode (LED), and photodetector (SFH 2701, Osram) with paper-based printed circuitry and a poly(methyl methacrylate) LFD holder (Figure 2). An RFID reader and antenna (AS3993-QF_DK_R FERMI, ams) were used to wirelessly scan the device and read out the optical information using the reader software. An Arduino setup was developed, allowing for ease of interaction with the RFID sensing chip through a serial peripheral interface (SPI). Previous work showed the successful implementation of temperature and resistance measurements for fluidic detection [5].

RESULTS AND DISCUSSION

Initial results for the low-cost color detector using model LFDs were compared with results recorded using a commercial LFD test strip reader (ESEQuant, Qiagen) (Figure 3). An updated design for the color detector

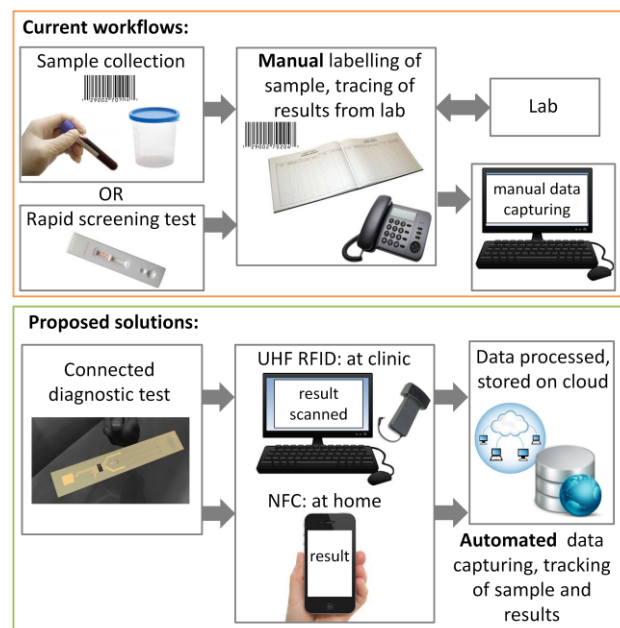


Figure 1: Current workflows for typical rural and resource-limited PHC clinics in South Africa, with proposed connected RFID solutions. Ultra-high frequency (UHF) RFID is suited to longer read ranges and on-site testing at clinics, while near-field communication (NFC) is appropriate for short read ranges up to a few cm, appropriate for home-based testing.

has been manufactured, incorporating a printed and assembled RFID tag instead of using the development kit (Figure 4). The wireless color detector can be powered using a coin cell battery or the RF field, which can also provide power to the LED when the device is in the range of the reader. Estimated costs for the current reader prototype would be under \$8 with the battery included. Costs would be expected to drop by an order of magnitude for mass production, providing a low-cost, reusable and connected color detector solution.

CONCLUSION

The potential for integrated printed electronics and paper-based diagnostics to achieve connected POC diagnostic solutions is highlighted in this work, with emphasis on RFID based implementations for wireless connectivity. Future implementations could include paper-based microfluidics integrated with the printed sensing RFID tag. The proposed solution can be used for tracking and identification of a diagnostic test, as well as for optical sensing to provide an integrated, automated and connected POC diagnostic solution using only a few components in a low-cost form factor.

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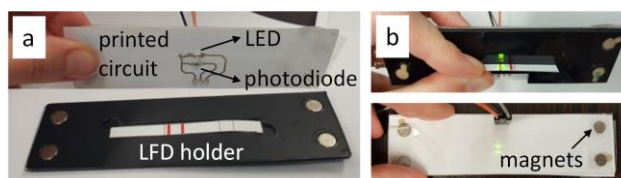


Figure 2: Color detector device comprised of a) inkjet printed circuit on photo paper with LED, photodiode and holder to house LFD, b) assembled device with connections to RFID development kit. Magnets were used for ease of device alignment and assembly.

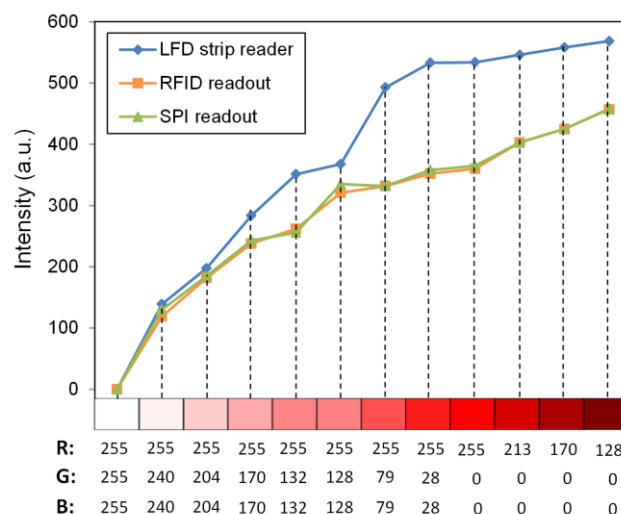


Figure 3: Color detector intensity readout for model LFDs comparing strip reader with SPI and wireless RFID readout. Relative intensity measurements were made by subtracting the background (blank) signal from the measured test signal.



Figure 4: Standalone color detector design with printed wireless RFID module included.