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DISTRIBUTED ELECTROCHEMICAL SENSORS: RECENT ADVANCES AND BARRIERS TO MARKET ADOPTION

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REVIEW

Distributed electrochemical sensors: recent advances and barriers to market adoption

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Abstract

Despite predictions of their widespread application in healthcare and environmental monitoring, electrochemical sensors are yet to be distributed at scale, instead remaining largely confined to R&D labs. This contrasts sharply with the situation for physical sensors, which are now ubiquitous and seamlessly embedded in the mature ecosystem provided by electronics and connectivity protocols. Although chemical sensors could be integrated into the same ecosystem, there are fundamental issues with these sensors in the three key areas of analytical performance, usability, and affordability. Nevertheless, advances are being made in each of these fields, leading to hope that the deployment of automated and user-friendly low-cost electrochemical sensors is on the horizon. Here, we present a brief survey of key challenges and advances in the development of distributed electrochemical sensors for liquid samples, geared towards applications in healthcare and wellbeing, environmental monitoring, and homeland security. As will be seen, in many cases the analytical performance of the sensor is acceptable; it is usability that is the major barrier to commercial viability at this moment. Were this to be overcome, the issue of affordability could be addressed.

Keywords Electrochemical sensors · Autonomous sensing · Ultralow-cost diagnostics · Distributed sensing networks · Remote sensing

Introduction

Scope

With the convergence of cloud computing, mobile devices, and global connectivity, information can be now transmitted, stored, shared, and accessed at any time, at any point on the planet, at near-zero cost. Combined with artificial intelligence, this technological revolution represents one of the most promising opportunities to solve some urgent global healthcare, security, and environmental problems (Fig. 1).

Indeed, building networked sensing devices that allow faster, simpler, and cheaper decision-making processes has become the new paradigm for human development in the twenty-first century. However, leveraging the power of the global network to reshape social systems requires that methods to generate information move from centralized models to decentralized (distributed) approaches. Scientific instruments, traditionally conceived to be produced on a small scale for laboratories and to be operated by experts, must now be redesigned for widespread deployment across distributed networks and for use by non-experts. The challenge to build new tools that simultaneously combine robust information, low cost, unsupervised operation (i.e. no user intervention), and resilience to changes in the surroundings may often require a compromise, as described by Valcárcel and Cárdenas in relation to the notion of "vanguard" analytical tools [1].

One important aspect to be considered in the development of decentralized systems is the impact of their applications and the directions that the development of social systems may take upon their adoption. Although this topic exceeds the limits of this review, as it requires a multifaceted analysis, two major ideas need to be stressed. Firstly, today's social systems—such as healthcare—cannot cope with current and future demands

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