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Proposed Implementation of Electronic Nose in the Hospital to Detect Methicillin Resistant Staphylococcus Aureus

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Abstract: This investigation pinpoints various applications of electronic noise in the medical field, to justify the proposed research and development of Electronic nose to recognize the smell MRSA in the hospital. Application of an electronic nose has been justified by many medical researchers as a promising intelligent device to give clinical diagnose to human diseases and to recognize many different pathogenic microorganisms. Research and Development of an electronic nose to recognize the smell of MRSA could be a way forward to prevent several difficult-to-treat infections in humans, to promoting early treatment from mild to severe before it spreads and cause outbreaks with a high mortality rate in the hospital.

Keywords: Electronic Nose; MRSA; Pathogenic; Microorganism; Disease, Medical area.

Introduction

Electronic nose is a replicate of the human olfactory lobe because of same stages of recognition process and its performances for identification, comparison, quantification and other applications not excluding data storage and retrieval. Application of an electronic nose has been justified by many medical researchers as a promising intelligent device to give clinical diagnose to human diseases and to recognize many different pathogenic microorganisms. Researchers have published experimental data in the last two decades to demonstrate the practicability of using the electronic nose.

Research and development of electronic nose to detect the smell of MRSA, to be place carefully in the hospital ventilation system or use in the hospital would yield outstanding results to prevent difficulties faced in treating diseased patients, also to prevent non-diseased patients and equipments from being contaminated. Application of an electronic nose in the hospital environment could be a way forward to promoting early treatment from mild to moderate then to serve stage before it spreads and cause outbreaks with a high mortality rate in the hospital.

Various Applications of Electronic Nose in Medical Field

Modern medicine faces difficulty and limitation of achieving successful disease diagnoses through early detection of pathogenesis or disease status in order to facilitate the utilization of rapid treatments. Chemical analysis of human biological samples, such as urine, blood, sweat, breath and skin are the major common means of diagnosing most pathological conditions but at the same time greatly reducing the invasiveness of diagnostic treatments. Clinical applications of e-nose technology which have been used and various studies have shown evidence of e-nose effectiveness at high accuracy in medical diagnosing. Many medical researchers have published experimental data in the last twenty years to demonstrate the practicability of using the electronic nose to diagnose human diseases and to recognize many different pathogenic microorganisms.

Shyknon*et al.* applied a commercial portable electronic nose (Cyranose C320) and recruited 90 patients with different ENT pathologies including chronic suppurativeotitis media, otitisexterna and nasal vestibulitis. After swabs diagnosis were taken and analyzed applying the e-nose device compared with the microbiological culture. Results proved that e-nose had of sensitivity of 82.2% which is a promising result. [1]

Thaler, *et al*. demonstrated the potential of e-nose approach by diagnosing bacterial sinusitis. They employed a nasal continuous airway mask to sample gas exhaled through the nose of patients with sinusitis and compared this with controls. In this study patients were examined infected if there was a positive culture from the swab sent to microbiology. They were able to predict accurately the diagnosis of sinusitis in 72% of samples, also to recognize infected patients and non-infected patients 82%. [2]

Bruno, *et.al*. illustrated the diagnostic application of the electronic nose examining patients suffering from chronic rhinosinusitis (CRS). They carried out a controlled study, grouping the patients into two, the ones suffering with CRS and the healthy ones. The result showed as high as 85% for the detection of the bacteria in patients with chronic rhinosinusitis compared to healthy patients using electronic technology. [3]

Pavlou, *et al*. presented the application of the electronic nose as a possible diagnostic tool for patients affected with kidney diseases by identifying the traces of blood in urine samples, and for the rapid identification of *E.coli*, *straphylococcus spp*. and Proteus spp. infections at very high level of confidence.[4]

Aathithan, *et al.* analyzed 534 clinical urine specimens of which 21% had outstanding bacteriuria indication. The sensitivity and specificity of the electronic nose compared with conventional cultural counts were 83.5% and 87.5% respectively, but the electronic nose diagnoses were done at remarkably lower costs. [5].

Gendron, *et al.* presented a report on the in vitro discrimination of tumor cell lines by application of an electronic nose. Cells from both tumor (squamous cell carcinoma, mesothelioma, adenocarcinoma) and normal healthy cell lines were suspended in saline solution and analyzed by the Cyranose 320 e-nose (Smith Detection, Pasadena, CA). The electronic nose could identify between cancer cell lines obtained from skin lesions and confirmed to have good sensitivity toward VOCs emitted from skin portions of patients affected by melanomas. [6]

Dutta*, et al.* applied the Cyranose 320 e-nose for in situ diagnostic analysis of patients in the hospital environment to recognize three different strains of Staphylococcus aureus bacteria responsible for ear, nose and throat infections. This utilized an innovative object-oriented data clustering approach to combining PCA base on three dimensional scatter plots using Fuzzy C Means(FCM)and a self-organizing map(SOP) network. The results proved that the Cyranose 320 was capable of recognizing the three bacterial aroma-subclasses of S. aureus strains with up to 99.69% accuracy. These results gave a clear support for a new rigorous tool, method for the detection and identification of S. aureus infections in hospital. [8]

Hockstein, *et al*. differentiated between diseased and non-diseased patients with an accuracy as high as 91.6%. The severity of asthma also was examined by use of the electronic nose in young and older patient with mild and severe asthma. [7]

Pavlou, *et al*. and Fend, *et al*. investigated the presence of Mycobacterium tuberculosis, etiologic agent of tuberculosis and a world-wide major public health issue especially in developing countries, both in vitro and in situ, by means of e-nose analysis of sputum samples of diseased patients. They were able to recognize the pathogen at very high level of accuracy (100% and 89%) in these specific sputum samples. [4, 11]

Fend*, et al*. applied the electronic nose in blood analysis to monitor and quantify dialysis dosage in patients undergoing regular renal dialysis following kidney failure. The dialysis dose is a function of the urea reduction rate and was detected by e-nose that was capable of recognizing pre-dialysis from post-dialysis blood. [11]

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Moens, *et al*., were able to reduce the time between isolation and identification of ten clinically merit microgansims(Pseudomonas aeruginosa,E coli, Klebsiella, E faecalis, Proteus vulgarisEnterobacteraerogenes, canadidaalbicans, Streptococcus pneumonia, Aspergillusfumigates, S. aureus) with the application of an electronic nose. [18]

Roine, *et al*., demonstrated the applicability of ion mobility spectrometry (IMS) used e-nose to discriminate the most common UTI pathogen from gaseous headspace of culture plates rapidly and without sample preparation and the bacterial species were identified with sensitivity of 95% and specificity of 96% using e-nose as compared to urine bacterial cultures. Further more these findings strongly demonstrated the ability of e-nose to discriminate bacterial cultures and provided a proof of principle to using method in urinanalysis of UTI. [14]

Julian, *et al.,* they applied an e-nose to the identification of pathogens from cultures and diagnosing illness from breath samples. Their initial results suggested that an e-nose will be able to assist in the diagnosis of disease in the near future. [13]

Drawback of Application of Electronic Nose in Hospitals

In this review, with all these outstanding and promising applications of electronic nose in clinical settings, however none of these medical researchers have demonstrated the application of E-Nose in the hospital ventilation system to detect smell of MRSA in the hospital environment, MRSA is responsible for several difficult to treat infections in humans. Applications of the electronic nose in the hospital is that if technically placed in the hospital ventilation systems or used in the hospital wards; it could detect and therefore prevent contamination of other patients or equipment by many highly contagious pathogens. The detection of dangerous and harmful bacteria such as MRSA (Methicillin-resistant Staphylococcus aureus) by specifically developed electronic nose could recognize the smell of MRSA in the hospital.

MRSA and MSSA

Methicillin-resistant Staphylococcus aureus (MRSA) is a subgroup within the group of organisms known as S. aureus. MRSA are distinguished by their resistance to treatment with frequently applied antibiotics, in contrast to the remainder of the Staphyloccocusaureus group which are defined as methicillin-susceptible S. aureus(MSSA). Both MRSA and MSSA can cause infection but individuals may also carry the organism without being infection by it. An individual, who carries the organism but is not infected, is regarded to be a carrier or colonized. 33% of healthy individuals carry staphylococcus aureus, including MRSA, mostly in their noses and also at other sites. Methicillin Resistant Staphylococcus aureus, MRSA is known as the hospital 'superbug' by virtue of its ability to spread and cause outbreaks with a high mortality rate of up to 60% [17].

Staphyloccusaureus arises to infections changing from not severe, e.g boils and infected cuts, to severe e.g infections of bones, lungs, heart and blood stream. MRSA is responsible for several difficult to treat infections in humans with antibiotics and has lead to involve this certain group of staphylococcus aureus, including MSSA and MRSA, which are competent of causing hospital-acquired infection [15,16].

Organism can be transferred to patients from contact with hands or directly from the environment. The hindmost includes from air, dust, clothing, soft furnishings, surfaces and equipment. [17]

Proposed Methodology

The proposed methodology is divided into four blocks respectively from figure.1, which are MRSA, Analog front end, Signal conversion unit, and Digital signal processor and pattern recognition engine.

Figure.1. From the sketch of a proposed implementation of electronic nose in the hospital to detect methicillin-resistant staphylococcus aureus. The analog front end consisting of suitable sensor array that would be incorporated with amplification and filtering circuits, to accurately recognize the smell of Methicillin-resistant Staphylococcus aureus with help of active response of volatile Organic compounds (VOCs). Amplifications are incorporated at each sensor to magnify the feeble signal. Filtering is introduced at each sensor to prevent unwanted signals or features from the feeble signal. Signal conversion unit which consists of analog to digital converter, converting analog signals to digital signals. Digital signal processor and pattern recognition engine consists of different stages of preprocessed. This in interphased with feature extraction subunit functioning as feature extraction and dimensionality reduction, classification with artificial neural network, validation, of microbial types and density. The Preprocessor modifies and processes the input signal to produce a signal void of interference as the output. Where dimensionality reduction reduces the number of random variables data under consideration of obtaining a set of principal variable by using feature extraction, to start from an initial set of measured data and to builds derived features intended to be informative and non-redundant, to facilitating the subsequent learning and generalization steps that would lead to better human interpretations. Classification using artificial neural network focuses on the recognition of MRSA patterns and regularities in data. Validation is the action of checking the accuracy of detection of microbial types and density (MRSA).

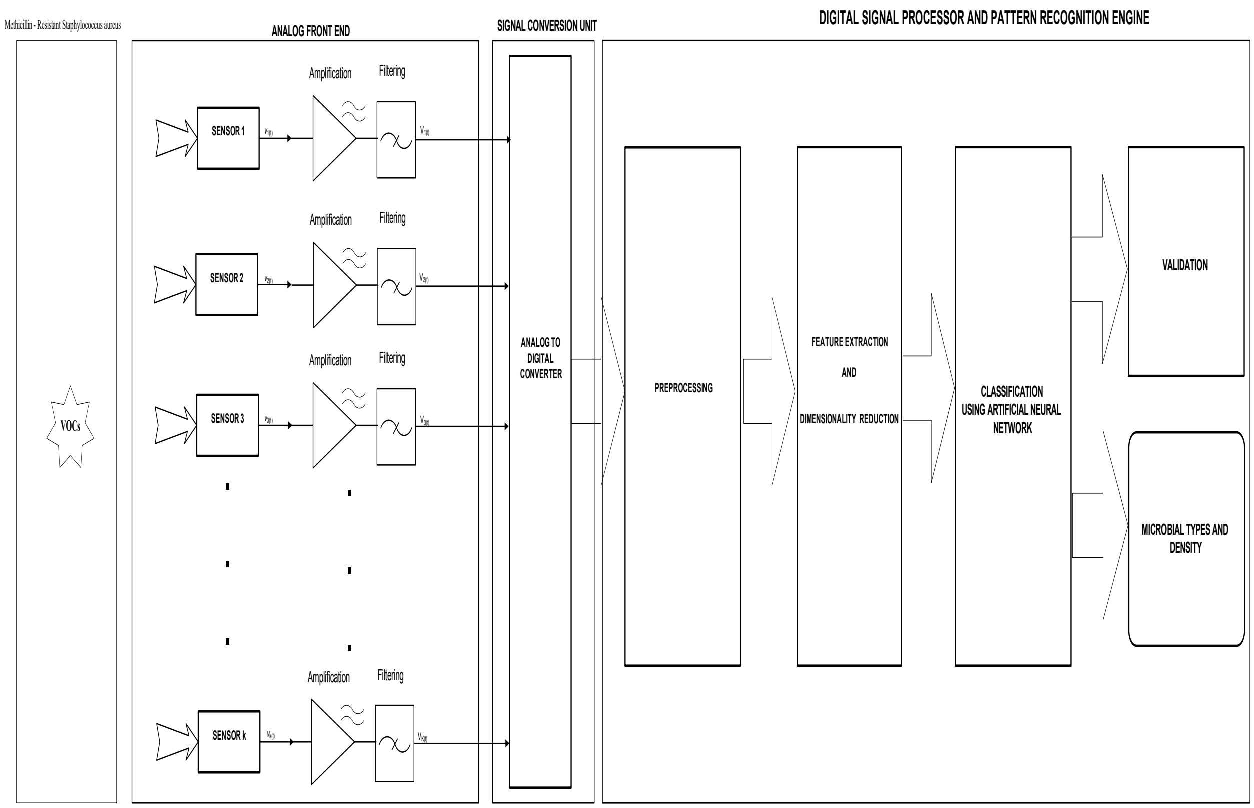

Fig1. *Proposed electronic nose to recognize the smell of Methicillin-resistant Staphylococcus aureus*

Conclusion

MRSA is known as the hospital 'superbug' by virtue of its ability resistant to several types of antibiotic, which causes difficult-to-treat infections in humans. Incorporating an Institute of electronic nose to recognize MRSA in the hospitals would facilitate the utilization of early rapid treatments and also assist to prevent difficulties in treating pathological patients, to prevent non-infected patients and equipments from being contaminated.

Recommendation

The authors would like to recommend incorporation of suitable filtering and amplification circuits in design and development of electronic nose in order to achieve clinical diagnostic human diseases and to recognize many different pathogenic microorganisms and also more researches should to be carried out on electronic nose for recognition of different pathogenic microorganisms in the hospital environment, there by promoting early detection and treatment from mild to moderate to serve cases before it spreads.

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