Methods and Systems for Rapid Antimicrobial Susceptibility Tests

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BRIEF DESCRIPTION

Rapid antimicrobial susceptibility testing (AST) is a method for quickly determining the most effective antibiotic therapy for patients with bacterial infections. These techniques enable the detection and quantification of antibiotic-resistant and susceptible bacteria metabolites at concentrations near or below ng/mL in complex media. Employing bacterial metabolites as a sensing platform, the system integrates machine learning data analysis processes to differentiate between antibiotic susceptibility and resistance in clinical infections within an hour. With the results, a clinician can prescribe appropriate medicine for the patient's bacterial infection.

SUGGESTED USES

·**Clinical Diagnostics:** Rapidly determine the most effective antibiotic therapy for patients with bacterial infections, leading to personalized treatment plans and improved outcomes.

·**Point-of-Care Testing:** Enable healthcare providers to conduct antimicrobial susceptibility tests quickly and efficiently directly at the point of care, reducing the time to initiate appropriate antibiotic therapy.

·**Surveillance and Epidemiology:** Monitor antibiotic resistance patterns in real-time at a population level, aiding in the early detection of emerging resistant strains and informing public health interventions.

·**Veterinary Medicine:** Facilitate the selection of optimal antibiotics for treating bacterial infections in animals, promoting responsible antibiotic use and combating antimicrobial resistance in veterinary settings.

·**Food Safety:** Assess the susceptibility of foodborne pathogens to antibiotics, helping to ensure the safety of food products and minimize the risk of antibiotic-resistant bacteria entering the food chain.

·**Environmental Monitoring:** Detect antibiotic resistance in environmental samples, such as water and soil, to track the spread of resistant bacteria and identify potential sources of contamination.

·**Research and Development:** Accelerate the development of new antibiotics and antimicrobial therapies by providing rapid feedback on their efficacy against a wide range of bacterial strains.

·**Biosecurity and Biodefense:** Enhance biosecurity measures by enabling the rapid identification of antibiotic-resistant pathogens in bioterrorism or biowarfare scenarios, facilitating prompt response efforts.

·**Antibiotic Stewardship Programs:** Support antimicrobial stewardship initiatives in healthcare facilities by guiding appropriate antibiotic prescribing practices and minimizing the overuse or misuse of antibiotics.

·**Global Health Initiatives:** Improve access to effective antibiotic therapy in resource-limited settings by providing affordable and portable diagnostic tools for rapid antimicrobial susceptibility testing.

These applications demonstrate the potential of the technology to address various challenges related to antibiotic resistance, infectious disease management, and public health worldwide.

ADVANTAGES

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OTHER INFORMATION

KEYWORDS

Antimicrobial Susceptibility Testing (AST), Rapid Diagnostics, Surface-Enhanced Raman Scattering (SERS), Machine Learning, Antibiotic Resistance, Metabolic Profiling, Spectroscopic Analysis, Personalized Medicine, Clinical Decision Support, Precision Antibiotic Therapy

CATEGORIZED AS

- **Biotechnology**
  - Food

1. Faster Treatment Decisions: Enables healthcare providers to quickly determine the most effective antibiotic therapy for bacterial infections, reducing the time patients spend on ineffective treatments and improving outcomes.

2. Precision Medicine: Facilitates personalized antibiotic therapy tailored to the specific susceptibility profile of the infecting bacteria, optimizing treatment efficacy and minimizing the risk of adverse reactions.

3. Reduction of Antibiotic Resistance: Supports antibiotic stewardship efforts by guiding appropriate antibiotic prescribing practices, helping to mitigate the spread of antibiotic-resistant bacteria and preserve the effectiveness of existing antibiotics.

4. Improved Patient Outcomes: Leads to better clinical outcomes by ensuring that patients receive timely and targeted antibiotic therapy, reducing the likelihood of treatment failure, complications, and mortality associated with bacterial infections.

5. Cost Savings: Reduces healthcare costs associated with prolonged hospital stays, additional diagnostic tests, and the use of broad-spectrum antibiotics, by streamlining the selection of effective antibiotic therapy.

6. Enhanced Infection Control: Strengthens infection control measures by identifying antibiotic-resistant pathogens quickly, enabling prompt isolation of infected patients and implementation of appropriate infection control protocols.

7. Optimization of Antibiotic Development: Accelerates the development of new antibiotics and antimicrobial therapies by providing rapid feedback on their effectiveness against a wide range of bacterial strains, facilitating the discovery of novel treatment options.

8. Global Health Impact: Contributes to global efforts to combat antimicrobial resistance and infectious diseases by improving access to rapid and accurate antimicrobial susceptibility testing, particularly in resource-limited settings.

9. Increased Efficiency in Research: Streamlines research efforts in antimicrobial resistance and infectious diseases by providing a reliable and high-throughput platform for evaluating the efficacy of novel antimicrobial agents and studying bacterial metabolism.

10. Empowerment of Healthcare Providers: Empowers healthcare providers with advanced diagnostic tools for making informed treatment decisions, enhancing their ability to deliver evidence-based care and improve patient outcomes.

These benefits highlight the transformative potential of the technology in advancing healthcare, combating antimicrobial resistance, and promoting patient-centered and cost-effective treatment strategies.

FULL DESCRIPTION

The technology described entails a comprehensive approach to rapid antimicrobial susceptibility testing (AST), aimed at expediting the determination of effective antibiotic therapy for bacterial infections. Here's a detailed breakdown of the components and processes involved:

Metabolic Profiling: The process begins by obtaining metabolic profiles of bacterial strains. This involves identifying and quantifying metabolites produced by bacteria, which can vary in response to antibiotic exposure. These profiles serve as indicators of the metabolic state of the bacteria and their susceptibility to antibiotics.

Surface-Enhanced Raman Scattering (SERS): Surface-enhanced Raman scattering is utilized as a sensitive spectroscopic technique to analyze the metabolic profiles obtained. SERS allows for the detection of molecular vibrations associated with specific chemical bonds within the bacterial samples. This generates spectral data that provide detailed information about the chemical composition of the samples.

Machine Learning Analysis: The SERS spectral data are then subjected to machine learning analysis. Machine learning models are trained to recognize patterns within the spectral data that correlate with antibiotic susceptibility or resistance. Various machine learning algorithms, such as variational autoencoders, support vector machines, convolutional neural networks, and Bayesian Gaussian mixture models, may be employed for this purpose.

Antibiotic Susceptibility Determination: The machine learning models evaluate the spectral data to determine the antimicrobial susceptibility properties of the bacterial strains. These properties may include:

Antibiotic susceptible metabolite profiles: Spectral patterns associated with bacterial strains that are susceptible to specific antibiotics.

Antibiotic resistance metabolite profiles: Spectral patterns indicative of bacterial resistance to certain antibiotics.

Antibiotic temporal response: Changes in spectral patterns over time in response to antibiotic exposure.

Antibiotic dosage response: Correlation between spectral features and varying antibiotic concentrations.

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Decision Making: Based on predefined criteria and thresholds, the technology makes decisions regarding antibiotic susceptibility. For instance, if the spectral data indicate susceptibility to a particular antibiotic according to established criteria, the technology may recommend that antibiotic for treatment.

Species and Strain Selection: The technology is applicable to various bacterial species and strains commonly encountered in clinical settings, including but not limited to Pseudomonas aeruginosa, Escherichia coli, Enterococcus faecalis, and Klebsiella pneumoniae.

Data Processing and Optimization: Prior to analysis, the SERS spectral data may undergo preprocessing steps such as smoothing, background subtraction, and scaling. These steps are aimed at improving data quality and enhancing the accuracy of subsequent analysis.

Model Training and Transfer Learning: Machine learning models are trained using datasets that establish the relationship between SERS spectral data and antimicrobial susceptibility properties of bacterial strains. Transfer learning techniques may be employed to leverage pre-existing knowledge and optimize the efficiency of model training.

Overall, the technology combines advanced spectroscopic methods, machine learning algorithms, and criteria-based decision-making to rapidly determine the most effective antibiotic therapy for bacterial infections, thereby improving patient outcomes and combating antimicrobial resistance.

STATE OF DEVELOPMENT

Prototype developed

OTHER INFORMATION

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