Inhaler System and Method for Detecting Valid Usage of the Inhaler System

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Abstract

Conventional inhaler systems, including metered-dose inhalers (MDIs) and dry powder inhalers (DPIs), play a critical role in the management of asthma, COPD, and other respiratory disorders. However, effective drug delivery depends on proper coordination between actuation and inhalation—an area where many patients struggle. Misuse, such as failing to inhale, exhaling into the device, or generating insufficient suction, results in poor therapeutic outcomes and leads to false-positive usage detection in smart inhalers. Existing single-sensor systems, particularly pressure-based methods, are prone to environmental interference and cannot confirm mouthpiece engagement. Temperature-based detection also suffers from ambiguity in ambient conditions and sensor contamination.

To overcome these limitations, this work presents a multi-modal smart inhaler system integrating three complementary sensing modalities:

1. A temperature sensor embedded within an internal channel to detect transient thermal gradients,
2. A pressure sensor in the airflow conduit to measure negative pressure during inhalation, and
3. A proximity sensor to confirm lip contact or oral cavity proximity.

All sensors are encapsulated beneath a hydrophobic microporous fluoropolymer membrane to prevent contamination while allowing airflow. A processing unit performs sensor fusion, usage validation, and storage of confirmed inhalation events, while communication interfaces such as BLE, Wi-Fi, or NFC enable secure transmission of adherence data. This multi-sensor framework offers a robust solution for accurately distinguishing true inhalation events from false usage, supporting more reliable respiratory monitoring and treatment adherence.

Keywords

Smart inhaler system, multi-modal sensing, respiratory monitoring, pressure sensing, temperature sensing, proximity detection, hydrophobic membrane.