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Proposed Artificial Intelligence (AI) Control Strategies for Enhancement of Solar Chimney Performance in Building

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This paper presents a comprehensive study on the application of solar chimney in buildings for heating, ventilation, and cooling, with a particular focus on the implementation of artificial intelligence (AI) techniques to optimize system performance and maintenance. The study explores the integration of AI for real time control, fault detection and predictive maintenance in solar chimney. This will enhance the performance of the solar chimney in building ventilation, heating and cooling.
Keywords: Solar chimney, Air flow optimization, Sustainable building design, Energy saving technologies, Artificial Intelligence etc.

1. Introduction

Structures play a vital role in our shift to a future with less carbon emissions. In addition to being our places of employment, residence, and relaxation, they account for roughly one-third of greenhouse gas emissions and roughly 40% of world energy use. In contrast to the 2.4% growth seen in 2022, the global demand for energy increased by 2.2% in 2023. While the demand for power in China, India, and many other Southeast Asian countries grew significantly in 2023, advanced economies saw significant losses as a result of a weak macroeconomic climate and high inflation, which lowered manufacturing and industrial output. Over the following three years, it is anticipated that the world's need for energy would increase more quickly, with an average annual growth rate of 3.4% until 2026 (IEA, 2024).

Although every business building has different energy requirements, space heating accounted for over 32% of all commercial building energy use in the United States in 2018. In terms of energy consumption in commercial buildings, ventilation and lighting came in second and third, respectively, using almost 10% of all energy used in commercial buildings in 2018. The highest consumption of electrical energy had been utilized in the space heating and ventilation. The similar results have been assumed for ventilation in India and space heating in cold places. The annual and regional differences in the proportional percentages of space heating and cooling are influenced by climate and weather (EIA, 2024).

The purposeful introduction of fresh air from the outside atmosphere into a place that has been equipped with air ventilation equipment is to eliminate and reduce the buildup of unwanted air pollutants indoors. Many residential, non-residential, and industrial structures must have air ventilation, which can be achieved mechanically, or naturally (Guo et al., 2021). For residential building applications, an effective ventilation system's ability to sustain thermal comfort is crucial, especially in rural areas with hot climates. In residential buildings, factors such as air flow, solar intensity, indoor temperature and relative humidity, and others basically determine the level of indoor thermal comfort (Guo et al., 2021; Sinden, 1997).

The experimental studies on Trombe wall or vertical solar chimney was carried out by Lal et al and observed that the ventilation rate of the building can be increased sufficiently by solar chimney and its integration approaches (Bansal et al. 1993, Hirunlabh et al. 1997, Lal et al. 2013, Mathur et al. 2005, Kaushik et al. 2013) and the mathematical modelling was developed by Ong & Chow (2003) for the analysis of performance of solar chimney. The solar chimney was modified by adding the metal box which filled by water and observed a better performance in all respect as ventilation, heating and cooling mode (Lal 2014), Hirunlabh 1999), it is also integrated with other possible ideas by which the performance in all three directions (ventilation, heating and cooling) had increased accordingly (Suhendri et al. 2022, Maerefat & Haghighi 2010, Dai et al. 2003, Gan & Riffat 1998, Camilo et al. 2019, Cao et al. 2021). The chimney is also optimised for better performance with the optimum air gap between glass and absorber, tilt angle of the glass and the inlet and exit opening sizes by Lal (2014), Bassiouny & Koran (2009), Belhadj et al. (2021), Chassapis et al. (2008), Koran et al. (2009), Lal (2014) and it was observed that the optimum air gap was 60 mm and optimum tilt angle 5° was recommended for best performance (Lal 2014).

The thermal conditioning of the building can also be improved by the help of solar chimney and it can be reduced the commercial energy consumption which leads to decrease the environmental pollution and increased the CO_2 mitigation (Lal 2012), Lal 2022). The techno-economic analysis was also carried out by Lal et al and found that approximately 2-5% cost of the building is increased due to the solar chimney retrofitting and the payback period observed less the 1-2 year for both base and modified chimney's (Lal 2022, Lal 2022. The overall benefit in the view of energy saving, money saving and environmental conservation and it leads to sustainable approach have been observed by various researchers. The integrated approaches of solar chimney can increasing the performance in terms of ventilation, heating and cooling of buildings where various integrated approaches were studied by the researchers like: solar chimney with earth air heat exchanger, solar chimney integrated with borehole heat exchanger, vertical solar chimney (Trombe wall) with inclined solar chimney, solar chimney with adsorption cooling system etc. (Kaushik 2013, Bharagava 2012, Jain et al. 2012.

More than 220 million buildings, or 75% of the building stock, are inefficient users of energy in Europe alone. Many of these buildings heat and cool using fossil fuels. Our System Value initiative's European analysis reveals that a 20% switch from heating to heat pump applications powered by renewable electricity would result in a 9% decrease in CO_2 emissions. When combined with clever solutions, the benefits to human health from reduced air pollution between now and 2030 might be worth €3 billion. Remember that any building built today will endure for at least the next 50 years, so making sure that both new and existing structures are green and decarbonized is essential to our efforts to tackle climate change (WEFORM 2021).

A main objective is to increasing the ventilation of buildings by utilizing the Solar Chimney to tap into the Sun's abundant heating potential. When it comes to a solar chimney, the heat from the sun warms the air within, which causes it to rise and produce a draft that drives the heated air out of the building. In the process of heating, hot air is expelled from the top of the chimney and cooler air from below is drawn in for heating. Ventilation within the structure is achieved through air movement, which is created by drawing in cooler air.

Positioning is among the most crucial factors to take into account when getting ready for a solar chimney. The solar chimney needs to be installed on a building's roof in a location where the sun shines naturally. Placing the chimney in a region that receives sunlight in the afternoon is the ideal circumstance. It's crucial to take the solar chimney's thermal properties into account while designing it and to use materials with the highest heat absorption capacity. This usually consists of insulated glazing, colored glass, and a black frame. It's also vital to keep in mind that the size of the solar chimney affects its effectiveness; the larger the chimney, the more efficient it will be.

Finding a way to direct the cool air toward the chimney's base in order to create a suction effect and allow for ventilation is another crucial step. For this process, one of two approaches is usually applied.

In the first method, cooler air is drawn in through the lowest level of the building's windows and directed toward the base of the chimney inside the home. This configuration is ideal for structures with potentially limited ground area surrounding them and doesn't require any underground work. The second approach uses an underground conduit. The air in the pipe cools underground and is finally dragged through the building to the base of the chimney. There, it is drawn in by suction and heated before being discharged from the solar chimney.

The solar chimney is the good option for passive ventilation, heating and cooling of buildings and AI can improve its efficiency, performance and sustainability. The maintenance of solar chimney can be scheduled through AI also. The work presented in this manuscript will leads to follow the AI system design and fulfill the scope of work to improve the efficiency and performance as well as it helps to take scheduled action towards maintenance.

2. Material and Methods

2.1 Basic Concept of Solar Chimney

A solar chimney is a passive solar heating and ventilation system that uses the sun’s heat to drive airflow through a building. It is an innovative and environmentally-friendly way to manage indoor temperatures and air quality by taking advantage of natural energy sources. Solar chimneys can be integrated into buildings for both heating and cooling purposes, as well as improving ventilation.

The components and working principle of an inclined solar chimney for passive heating and ventilation are shown in Figure 1. A Trombe wall's (Collector) function and efficiency depend on a region's environmental or climate conditions. In Figure 1(a) heating is done by closing the outlet opening of the chimney with the help of a damper and the ventilation or removal of the stale air the outlet opening has to be open as shown as Figure 1(b). A solar chimney generally consists of three key components: Solar Absorber (Collector): This is usually a black surface or panel that absorbs sunlight and converts it into heat. It can be placed on the roof or on a vertical wall to maximize exposure to the sun. Chimney Shaft (Vertical Shaft): The vertical duct or chimney that allows warm air to rise. As the air heats up, it becomes less dense and rises naturally through the chimney, creating a pressure difference that draws air from the building. Ventilation Openings: These are openings in the building, usually located on the floor or in rooms where the air needs to be circulated. These openings allow fresh air to be drawn into the building as the hot air is vented out through the chimney.

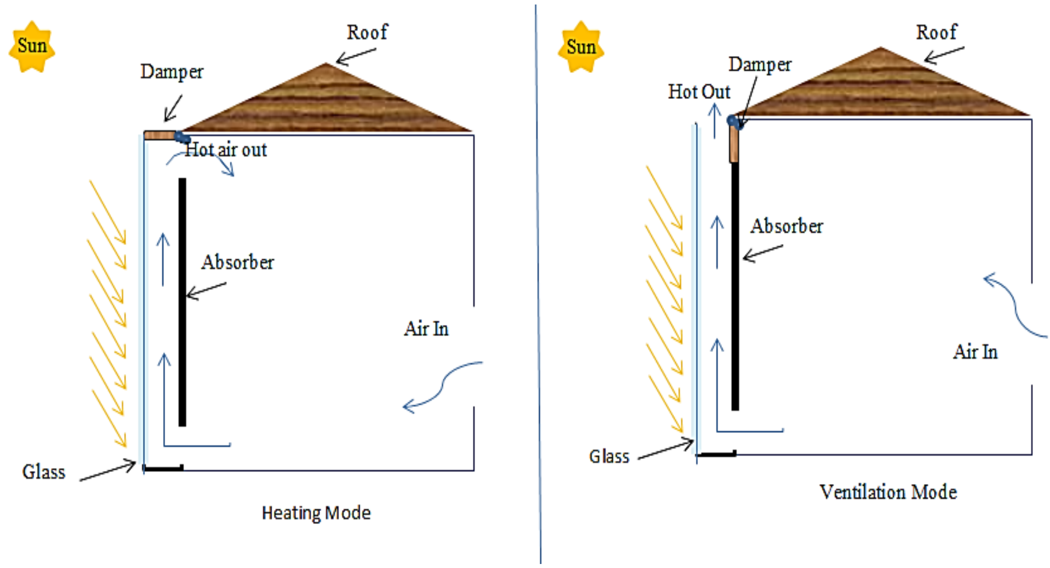


Figure 1: (a) Trombe Wall and (b) inclined Solar Chimney

The most important benefits of Solar Chimneys are discussed here as follows: Energy Efficiency: Solar chimneys use the sun's free energy to improve the thermal comfort of a building, reducing the need for energy-intensive heating and cooling systems. Sustainability: By reducing reliance on electricity and fossil fuels for heating, cooling, and ventilation, solar chimneys contribute to reducing the building's carbon footprint. Cost-Effective: While the initial installation of a solar chimney may involve some cost, the long-term savings on energy bills make it a financially viable option over time. Indoor Air Quality: The system enhances natural ventilation, helping to flush out stale air and bring in fresh outdoor air, which is especially beneficial in tightly sealed, energy-efficient homes. Passive Design: Solar chimneys are part of a passive building design, which means they rely on natural forces (sunlight, air pressure) instead of active, energy-consuming systems.

The Solar Chimneys can also improve the ventilation of buildings in various flow aspects which are described as: Natural Airflow: The solar chimney creates passive airflow by relying on the sun's heat to initiate air movement. This reduces the need for mechanical ventilation systems (such as fans or air conditioning), which consume electricity and increase energy costs. Removal of Stale Air: As hot air rises through the chimney, it helps to expel stale indoor air, which can contain pollutants, excess moisture, CO2, and volatile organic compounds (VOCs). This helps to improve indoor air quality (IAQ) by continuously circulating fresh air into the building. Continuous Ventilation: Solar chimneys can provide continuous, 24/7 ventilation as long as there is sunlight to heat the chimney. This is especially valuable in areas with limited wind or in buildings that require consistent airflow. Humidity Control: In buildings with high humidity (such as those in tropical climates), solar chimneys can help regulate indoor moisture levels by venting humid air out of the building and bringing in drier air. This can prevent mold growth, condensation, and other moisture-related problems.

2.2 Design Considerations and challenges of solar chimney

The orientation, size and location, materials, integrated with building design and seasonal variations are the design consideration for solar chimney which are described as follows: Orientation: The chimney should be oriented to maximize exposure to the sun, typically on a south-facing wall in the northern hemisphere; Size and Location: The dimensions of the chimney and its placement in the building will depend on the building size and the local climate. A larger chimney shaft and a higher temperature differential will lead to more efficient airflow; Materials: Choosing materials that maximize heat absorption, such as Dark-colored surfaces for the collector and durable materials for the chimney structure is important; Integration with Building Design: Solar chimneys can be integrated into both new and existing buildings. In new construction, the chimney can be designed as a core feature, while retrofitting may require placing collectors on the roof and adding vents and Seasonal Variation: In some climates, additional features like thermal storage or shading may be needed to ensure comfort across different seasons.

The most common challenges of solar chimney are labeled as follows:

- Effectiveness in Cloudy Weather: Solar chimneys rely on sunlight to create the temperature differential that drives the airflow, so their performance may be reduced on cloudy or overcast days.

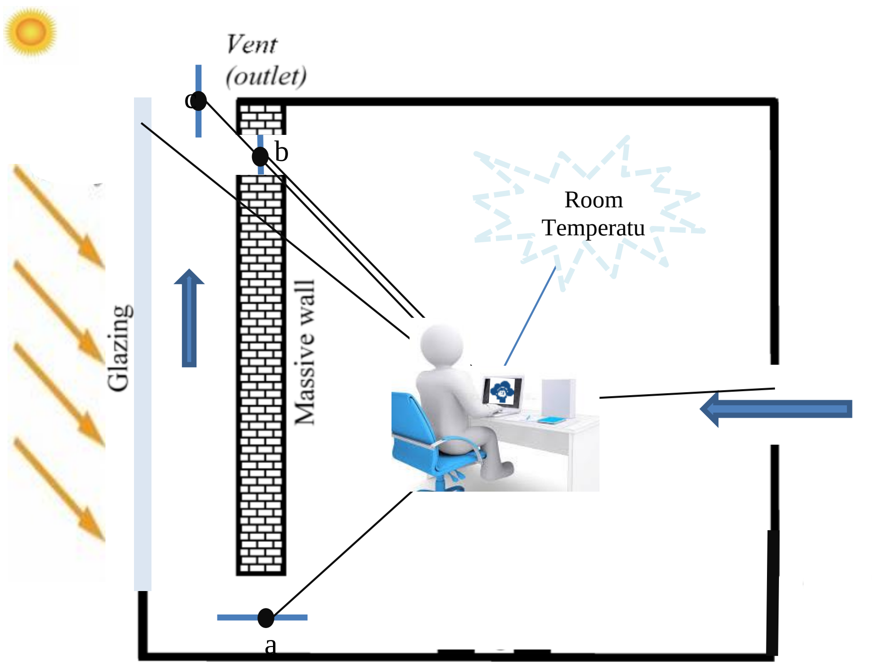
- Space Requirements: A well-sized chimney shaft requires a certain amount of space in the building, which may be difficult to accommodate in smaller homes or buildings with complex layouts.

- Maintenance: Solar chimneys require minimal maintenance, but the chimney shaft should be periodically inspected for obstructions or wear, and the solar collectors should be cleaned regularly to ensure efficient operation.

3. AI Operation of Solar Chimney Systems

Improved performance and fewer system needs can result from applying artificial intelligence (AI) to optimize the design parameters of renewable energy sources, such as solar energy systems (Marwa et al. 2023). AI techniques have been used to improve accuracy and precision in a variety of solar energy system-related tasks, such as design, forecasting, control, and maintenance (Gitanjali 2023). AI may also be used to monitor batteries, identify power converter and filter faults, and optimize the operation of inverters in grid systems to increase the quality of the power (Gitanjali 2023). Artificial intelligence (AI) can also be applied to solar photovoltaic (PV) systems to guarantee efficient energy supply and tackle issues in the renewable energy industry (Cesar & Saenz 2023). Moreover, artificial intelligence (AI) methods, including intelligent maximal power point tracking, can improve PV devices' energy efficiency, especially in partially shadowed conditions with dynamic changes in ambient parameters (Rajeshwari et al. 2023). All things considered, artificial intelligence holds great promise for raising the effectiveness and efficiency of solar energy systems.

The AI system can optimize the natural ventilation, heating, and cooling capabilities of the solar chimney by analyzing environmental conditions, predicting system behavior, and adjusting its operation dynamically. Below, will explain how AI can operate and optimize a solar chimney system, along with a block diagram to illustrate the system's functioning in figure 2 (i and ii). The chimney controlled by AI tools where it is operated two modes by Chimney damper by changing the conditions for Room Ventilation mode at the condition of damper (a) always open and damper (b) closed and damper (c) open; For Room heating damper (a) and (c) remains open and (b) change to be closed which is clearly explained in figure 2(ii).



Chimney damper conditions for Room Ventilation mode at the condition of damper (a) always open and damper (b) closed and

Figure 2; AI Controlled the parameters to run the solar chimney

The AI system is controlling the ventilation in the room in warm humid condition where it sense the ventilation required for the room for which it controls the air inlet and position of dampers as well as the tilt angle of glazing to increase the air flow rate.

AI technologies can significantly enhance the operation of solar chimney systems by providing real-time control, fault detection, and performance optimization. The AI system can optimize the natural ventilation, heating, and cooling capabilities of the solar chimney by analyzing environmental conditions, predicting system behavior, and adjusting its operation dynamically. Below, will explain how AI can operate and optimize a solar chimney system, along with a block diagram to illustrate the system's functioning.

3.1 Overview of AI enabled Solar Chimney Operation management system

Advanced artificial intelligence approaches are utilized by AI-enabled Solar Chimney Operation Management Systems to maximize efficiency and improve performance. In order to analyze geometric and environmental variables, like chimney height and collector radius, which have a significant impact on power output; these systems use a variety of methodologies, such as Artificial Neural Networks (ANN) and Adaptive Neuro-Fuzzy Inference Systems (ANFIS) (Assari et al. 2024, Ayli et al. 2021). The AI enabling Management system can operate through the method of optimization and energy management method, such as: Methods of Optimization: Artificial Neural Networks (ANN): Shown to perform better than conventional techniques in accurately estimating power output (Jeffery et al. 2021). According to Assari et al. (2024) the Adaptive Neuro-Fuzzy Inference System (ANFIS) provides a strong method for geometrical optimization that outperforms numerical techniques; Energy Management: Predictive analytics: To maximize energy storage and distribution, AI systems evaluate sensor data and weather projections (Anilkumar et al. 2023). Efficiency Gains: By cutting expenses and energy waste, these technologies increase the sustainability of renewable energy sources (Anilkumar et al. 2023). While AI techniques hold considerable potential for improving the performance of solar chimneys, there are still issues with connecting these systems with the current energy infrastructure and guaranteeing their dependability in a variety of environmental circumstances.

A solar chimney uses the principle of the stack effect—the tendency of warm air to rise, creating natural ventilation. It consists of a solar collector that absorbs heat, a chimney or vent stack where hot air rises, and a ventilation system that ensures airflow is directed through the building to enhance natural cooling or heating. The sensors are used for control of temperature, humidity and air flow rate and the damper opening required according the desire. The sensors also required to measure the environmental factors such as temperature, humidity, solar radiation, and airflow. The intelligent controller system is used to processes sensor data, makes decisions, and adjusts the system parameters as shown in figure 3.

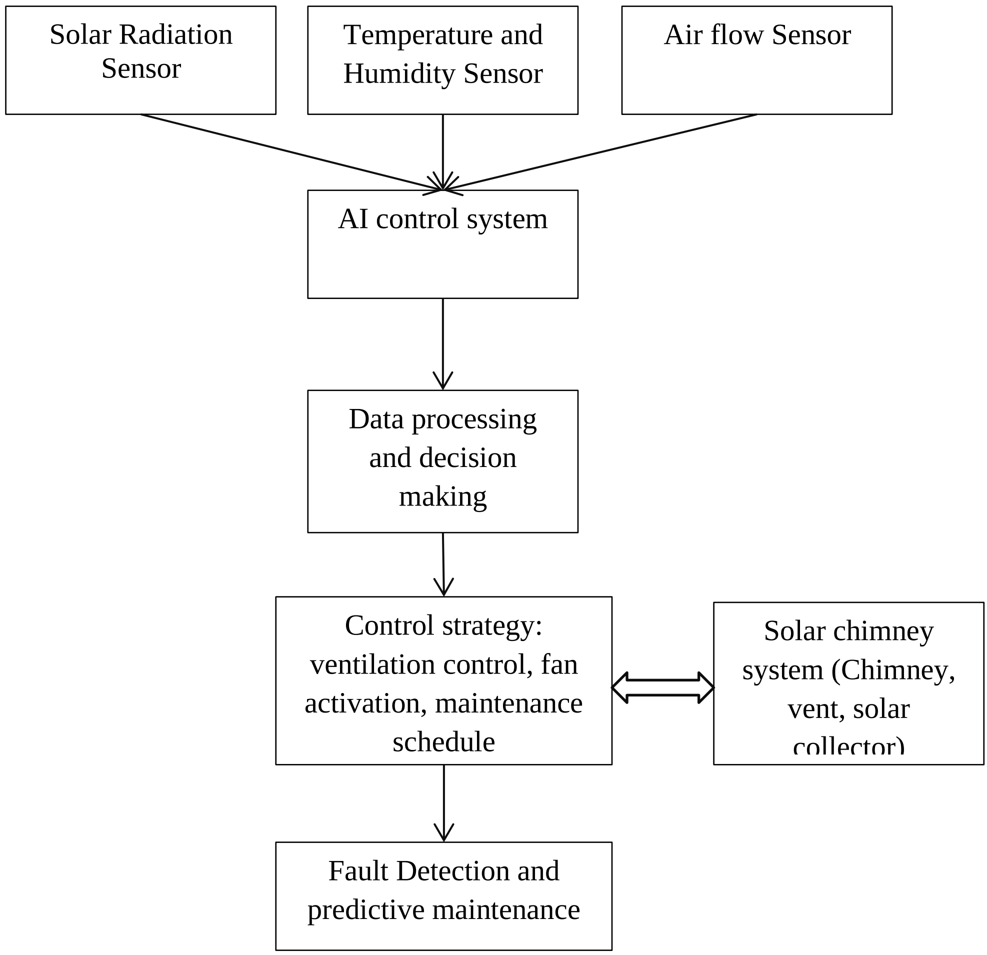


Figure 3: AI operating strategy for solar chimney

3.2 AI Operating management for Solar Chimney System

AI can manage and optimize the solar chimney in several ways, including Data Collection and Monitoring, Real-Time Analysis and Decision Making, AI-Controlled Adjustments for vent, fan and chimney; Predictive Maintenance and Fault Detection which is presented in figure 3 and described as follows:

3.2.1 Data Collection and Monitoring

The system continuously monitors various data points, such as:

- Solar Radiation: The amount of sunlight hitting the collector.
- Indoor Temperature and Humidity: For thermal comfort control.
- Outdoor Temperature: Impacts the effectiveness of the stack effect.

- Airflow: Monitors the rate of air moving through the system.

Sensors placed at key locations (e.g., inside the building, within the chimney, near the collector) collect real-time data.

3.2.2 Real-Time Analysis and Decision Making

The AI system analyzes the data using machine learning algorithms, often in combination with statistical models. Common techniques include:

- Supervised Learning: Train models on historical data to predict temperature fluctuations and airflow based on different weather conditions.

- Reinforcement Learning (RL): AI can adjust the operation of the chimney to maximize efficiency (e.g., ventilation, cooling, heating) based on feedback from the environment.

- Anomaly Detection: The system identifies unusual patterns in sensor data (e.g., unexpected airflow drop) that may indicate a fault.

3.2.3 AI-Controlled Adjustments

Based on the real-time data, AI can make adjustments, such as:

- Vent Control: The system can open or close ventilation openings based on indoor temperature and airflow.

- Fan Activation: If the natural stack effect is insufficient, auxiliary fans can be activated to boost airflow.

- Chimney Operation: The AI may adjust the size or the operation of the chimney depending on whether cooling or heating is needed.

3.2.4 Predictive Maintenance and Fault Detection

AI can predict when components such as the fans, vents, or solar collector need maintenance. By continuously tracking performance metrics (like airflow or temperature trends), the system can schedule maintenance or alert the building managers to potential issues before they cause system failure.

3.2.5 Energy Optimization

AI can optimize the solar chimney system in coordination with other building systems (like HVAC). For instance:

- In summer, the AI might use the solar chimney to increase natural ventilation and reduce reliance on mechanical cooling.

- In winter, the AI can enhance the stack effect for passive heating, potentially reducing energy costs.

3.2.6 Benefits of AI in Solar Chimney Operation:

➢ Real-time Adaptation: The AI can adjust the system in real-time, optimizing performance for both comfort and energy efficiency.

- Energy Efficiency: By leveraging solar radiation data and indoor conditions, AI can maximize the use of natural ventilation and passive heating/cooling, reducing energy consumption and reliance on HVAC systems.
- Predictive Maintenance: AI can predict when components will fail or require maintenance, reducing unplanned downtimes and increasing the lifespan of the system.
- Fault Detection: By analyzing sensor data, AI can identify anomalies in the system's behavior, such as airflow reductions or temperature fluctuations, and trigger maintenance or system adjustments before a breakdown occurs.
- Improved Indoor Comfort: The AI system can adjust airflow and temperature, ensuring optimal indoor conditions (e.g., temperature, humidity), improving occupant comfort without heavy reliance on artificial cooling/heating.

4. AI Applications for Optimization in Solar Chimney Systems

4.1 Optimization of Airflow and Ventilation

AI can dynamically adjust the solar chimney's operation to optimize natural ventilation and thermal comfort inside the building.

- Reinforcement Learning (RL) can be used to control the vent openings and activate auxiliary fans based on environmental conditions (e.g., temperature, solar radiation, indoor humidity). Example: During the summer, when solar radiation is high, the AI learns to open the vents fully to facilitate maximum cooling. In winter, it adjusts vent openings to optimize passive heating, minimizing the need for artificial heating systems.
- Model Predictive Control (MPC) can predict ventilation needs based on external weather conditions and adjust the system accordingly. MPC forecasts the future temperature, humidity, and airflow conditions, helping the system adjust its operation in advance. Example: The AI predicts a temperature spike and adjusts the vent system before indoor conditions become uncomfortable.

4.2 Thermal Comfort and Temperature Regulation

The application of artificial intelligence (AI) in a variety of models and techniques is essential to improving thermal comfort. Recent research shows that artificial intelligence (AI) systems, especially those that use causal frameworks and shallow supervised learning, are quite good in optimizing indoor environments. Important conclusions consist of Artificial Intelligence Models for Thermal Comfort as Artificial Neural Networks (ANNs) and Casual AI models are as follows: Trained on extensive datasets like as ASHRAE, these models have demonstrated a learning accuracy of up to 96.1%, efficiently adjusting to various home (Bras et al. 2024). According to Sahoh et al. (2024), these models use causal linkages to improve understanding and happiness by predicting human thermal comfort based on physiological and environmental aspects. The challenges and solutions are proposed as follows: Data Restrictions: Artificial intelligence (AI) systems frequently encounter problems like over fitting as a result of inadequate or faulty training data (Sahoh et al. 2024). Hybrid Approaches: Integrating ANNs with conventional control algorithms (like PID) can enhance adaptability in dynamic environments, especially in HVAC systems (Cullen et al. 2023). Although AI greatly improves thermal comfort solutions, the complexity of human preferences and environmental variability still poses a challenge, requiring continued research and development in this area.

AI can enhance the stack effect (natural convection) by optimizing airflow based on both indoor and outdoor temperature gradients.

- Neural Networks (NNs) can predict future indoor temperatures and adjust the ventilation rate to maintain thermal comfort. These networks process data such as solar radiation, outdoor temperature, and current indoor conditions to predict the best ventilation strategy.

Example: If the AI predicts that the indoor temperature will rise rapidly in the afternoon, it may open vents in advance to allow for passive cooling.

- Fuzzy Logic: AI can use fuzzy logic to manage ventilation based on multiple variables, providing smooth control and avoiding sudden changes that may affect thermal comfort.

4.3 Energy Efficiency Optimization

AI-driven optimization algorithms can minimize energy consumption while maintaining the desired indoor conditions.

- Optimization Algorithms (Genetic Algorithms, Particle Swarm Optimization) can search for the optimal configuration of vents, fan speeds, and solar collector settings to maximize energy efficiency while maintaining the building's comfort.

Example: AI can determine the most energy-efficient balance between natural ventilation and mechanical systems by adjusting the operation of the solar chimney based on the solar radiation and the building's energy needs.

- Energy Management Systems (BEMS): AI can integrate with a building's energy management system to ensure that the solar chimney works in tandem with other HVAC systems. It can optimize the use of both natural ventilation and mechanical cooling/heating based on real-time data.

4.4 Predictive Maintenance and Fault Detection

AI systems continuously monitor sensor data to detect faults before they cause a significant failure. Predictive maintenance can significantly reduce downtime and maintenance costs.

- Anomaly Detection (using techniques like Auto-encoders and K-Means clustering) identifies irregularities in system data such as airflow, temperature, and fan performance.

Example: If airflow unexpectedly drops while solar radiation remains high, AI can detect the anomaly and alert maintenance personnel to check for blockages in the ducts or malfunctioning fans.

- Predictive Maintenance Models use historical performance data and machine learning to predict when components such as fans or motors are likely to fail. By scheduling maintenance ahead of time, the system ensures optimal performance and reduces unplanned downtime.

5. Conclusion

A solar chimney is a simple yet effective solution for optimizing the heating, cooling, and ventilation of a building. By harnessing the sun's natural energy, it can provide passive, energy-efficient temperature regulation and improve indoor air quality. Though it may require careful design and consideration of local climate conditions, the solar chimney is an excellent addition to sustainable building practices, reducing both energy costs and environmental impact.

A solar chimney for space ventilation is a highly effective, sustainable, and cost-efficient way to improve indoor air quality, regulate temperatures, and reduce energy consumption in buildings. By harnessing solar energy, the system passively creates natural airflow, continuously ventilating indoor spaces without the need for mechanical ventilation systems. Proper design and integration into a building's architecture are crucial for optimizing performance. Although challenges like dependence on sunlight and space requirements exist, the long-term benefits of energy savings, improved indoor air quality, and environmental sustainability make solar chimneys a valuable solution for modern buildings aiming for energy efficiency and eco-friendliness.

Enhancing the performance of a solar chimney involves several key strategies, including optimizing the solar collector design, improving airflow dynamics, integrating thermal mass, using hybrid solar-powered fans, and considering the building's specific climatic conditions. By implementing these measures, the solar chimney can operate more efficiently, providing better natural ventilation, reducing energy consumption, and improving indoor air quality while keeping the system cost-effective and environmentally friendly.

Incorporating technology like smart sensors, automated controls, and monitoring systems can also further enhance performance and ensure that the solar chimney operates optimally year-round.

A techno-economic analysis of solar chimneys provides critical insights into their viability as an energy-efficient building system. While the initial capital cost can be significant, the long-term savings in energy, combined with the environmental benefits, often make solar chimneys a highly beneficial investment. By leveraging tools like payback period, NPV, IRR, and LCOE, building owners, architects, and engineers can assess the economic attractiveness of these systems and make informed decisions on their adoption

The implementation of AI in the analysis and optimization of solar chimneys can vastly improve their performance and efficiency. AI technologies like machine learning, reinforcement learning, predictive maintenance, and real-time control systems enable solar chimneys to adapt to changing environmental conditions, enhance energy savings, and ensure long-term reliability. With AI, solar chimneys can become an even more powerful tool for sustainable buildings, contributing to energy efficiency, indoor comfort, and environmental sustainability

AI integration into the operation of solar chimney systems offers numerous advantages, from dynamic optimization of energy use to proactive maintenance. By continuously processing real-time sensor data, AI enables solar chimneys to adapt to changing conditions, ensuring efficient operation and enhanced indoor comfort. Additionally, AI's predictive maintenance capabilities and fault detection features increase system reliability, reduce operational costs, and extend the system's lifespan.

AI-driven optimization of solar chimney systems enhances the overall efficiency, comfort, and sustainability of buildings. By continuously monitoring environmental and operational conditions, AI can adjust the system's performance in real time to ensure optimal ventilation, temperature regulation, and energy efficiency. Moreover, AI plays a crucial role in predictive maintenance and fault detection, minimizing the risk of failure and maximizing the longevity of the system. The integration of AI provides a smarter, more adaptable solar chimney system that can meet the demands of modern, energy-efficient buildings.

Conflict of Interest:

There is no conflict of interest.

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