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Adaptive HVAC Operation To Reduce Disruptive Fan Noise Levels During Noise-Sensitive Events

Paul Gyugyi

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BACKGROUND

Some heating, ventilation, and air condition (HVAC) systems produce a significant amount of noise. Such systems typically have a fan that is active when heating or air conditioning is occurring. Noise generated by such a fan can be disruptive to one or more occupants of the structure in which the HVAC system is located, especially if the one or more occupants are participating in a noise-sensitive activity.

DESCRIPTION

Some activities performed by one or more occupants of a structure may be particularly noise-sensitive. For example, one or more occupants may be participating in a conversation, phone call, watching a television program, listening to an audio program, or participating in some other form of activity during which sound generated by an HVAC system may be disruptive. Embodiments detailed herein are focused on determining when or predicting when such noise-sensitive events are occurring or are likely to occur and adjusting control of an HVAC system to decrease or eliminate the sound generated by the HVAC system (e.g., by the fan of the HVAC system) while the noise-sensitive events are occurring.

Data gathered using subsystem one may serve to determine when a sound sensitive activity is occurring or will likely occur in the future. A “sound sensitive” event or activity can refer to an event during which unwanted noise would be undesirable by participants in the event. Subsystem one may be referred to as a sound detection and/or prediction system, as indicated in fig. 1. Subsystem one may include one or more smart home devices that are located with a structure (e.g., home, office, building, apartment, condo, etc.). Such smart home devices may include thermostats, smoke detectors, carbon monoxide detectors, streaming video cameras, smart doorbells, home assistants, smart appliances, computer systems, mobile devices, smartphones, etc. Such smart home devices may have onboard microphones and/or onboard occupancy sensors (e.g., a passive infrared (PIR) sensors) which can detect sound and/or whether

one or more occupants are present in the vicinity of the smart home device. Subsystem one may include a smart television, smart television receiver device, smart set top box, or smartphone (or tablet) application that has access to television programming guide information and/or viewer history that may be used to predict when one or more occupants of the structure may be planning on viewing television content. Television programming guide information may be used to determine when commercial breaks are occurring or are likely to occur. Subsystem one may also be able to determine the status of the television, such as whether it's powered on, what channel the television or television receiver is set to, and/or what the output audio volume level is. In some embodiments, subsystem one may include a smart phone application that allows a user to indicate which television program is being viewed or will be viewed. For instance, an integrated smart phone application may allow for control of the output of a television and may also be used to provide subsystem one with an indication of when a sound sensitive viewing event is going to be occurring. In some embodiments, a sound sensitive event may be present if the output audio volume level is below a defined threshold. Above such a threshold, it may be assumed that the output volume is loud enough to drown out the sound of a HVAC fan.

Subsystem one may additionally or alternatively include a telephone, smartphone, or other smart device that can alert subsystem two when a conversation is being conducted using the device. For example, a smartphone may report to subsystem two that an active phone call is occurring. In other embodiments, such conversations may be determined based on audio being captured using one or more smart home devices. For example, a microphone in a home assistant device may be used to determine that a conversation is occurring nearby. The home assistant device could report to subsystem two that a conversation is occurring and, possibly, indicate a volume level of the conversation. Since the particular words spoken in the conversation are inconsequential, such activities may be performed without any form of recording of the conversation.

Subsystem one may include a hub device that receives data from one or more of the smart home devices and determines if a sound sensitive activity is occurring. The hub device may also predict whether a sound sensitive activity is likely to occur. For instance, if one or more occupants typically watches a particular weekly television program, the hub device may determine that based on this viewership history and the upcoming schedule of television

programs, one or more occupants may desire quiet at least during the noncommercial portions of the next episode of the television program. The hub device may provide data to subsystem two indicative of: 1) currently occurring sound sensitive events; and/or 2) upcoming predicted sound sensitive events. In some embodiments, rather than a hub device integrated as part of subsystem one performing such determinations, data may be provided via a network, such as the Internet, to a cloud-based processing system. The cloud-based processing system may include one or more computer server systems that are accessible by subsystem one and/or subsystem two via the Internet. The cloud-based processing system may use the data gathered by the one or more devices of subsystem one to identify 1) currently occurring sound sensitive events; and/or 2) upcoming predicted sound sensitive events.

Subsystem two may communicate directly with subsystem one or may communicate with subsystem one via a network, such as the Internet, or may receive instructions and communicate with a cloud-based processing system. Subsystem two, as indicated in fig. 1, may be referred to as an HVAC control system. Subsystem two may include a smart thermostat or subsystem two may communicate with a smart thermostat. Subsystem two may be able to control or adjust a thermostat schedule that includes multiple temperature setpoints. Each setpoint may be associated with a temperature and a time. Subsystem two may be permitted to temporarily adjust a temperature of a setpoint and/or a time at which a temperature setpoint is enforced. For example, a temperature set point may not be enforced until a sound sensitive event is determined to be over. Additionally or alternatively, subsystem two can activate the HVAC system ahead of an anticipated sound sensitive event. Therefore, in anticipation of a sound sensitive event, the interior of a structure may be heated or cooled preemptively.

In such embodiments, a heating or cooling schedule may not be affected, but a lower fan speed may be used, which may involve the HVAC system operating for a longer period of time. In some embodiments, subsystem two, if provided a likely schedule of an activity being performed by the one or more occupants, subsystem two may perform detailed scheduling of operation of the HVAC system. For example, if cloud-based processing system or subsystem one provides subsystem two with an indication of a particular television program or channel that the one or more occupants are viewing, subsystem two may be able to schedule HVAC operation for during commercial breaks and/or in between television programs.

In some embodiments, rather than subsystem two controlling the HVAC system directly, subsystem two may produce a temperature set point schedule that will reduce the likelihood or eliminate the likelihood that the HVAC system will be activated while a sound sensitive event is occurring. For instance, subsystem two may produce a temperature set point schedule for use during a television program that will reduce or eliminate the likelihood that the HVAC system will be activated. For instance, the temperature set point may be reduced such that a heating system and its fan is less likely to be activated.

Subsystem two may include one or more thermostats or one or more controller devices that communicate with one or more thermostats. Such thermostats may be in direct communication with an HVAC system, such as via control wires. Via signals applied to such control wires, a heating system (e.g., furnace), a cooling system (e.g., an air conditioner), and/or a fan may be activated and controlled. In some embodiments, a user may be permitted to provide input indicating when a sound sensitive event is occurring or will occur. Based off of the user's indication, subsystem two may adjust how the HVAC system is controlled such that little or no sound is produced during the sound sensitive event.

ABSTRACT

Some heating, ventilation, and air condition (HVAC) systems produce a significant amount of noise. Such systems can have a fan that is active when heating or air conditioning is occurring to circulate air. Noise generated by such a fan can be disruptive, especially if one or more nearby persons are participating in a noise-sensitive activity, such as watching television or talking. Embodiments are focused on determining when such noise-sensitive events are occurring or are likely to occur and adjusting control of an HVAC system to decrease or eliminate the sound or noise generated by the HVAC system while the noise-sensitive event is in progress.

Title: **Adaptive HVAC Operation to Reduce Disruptive Fan Noise Levels During Noise-Sensitive Events**

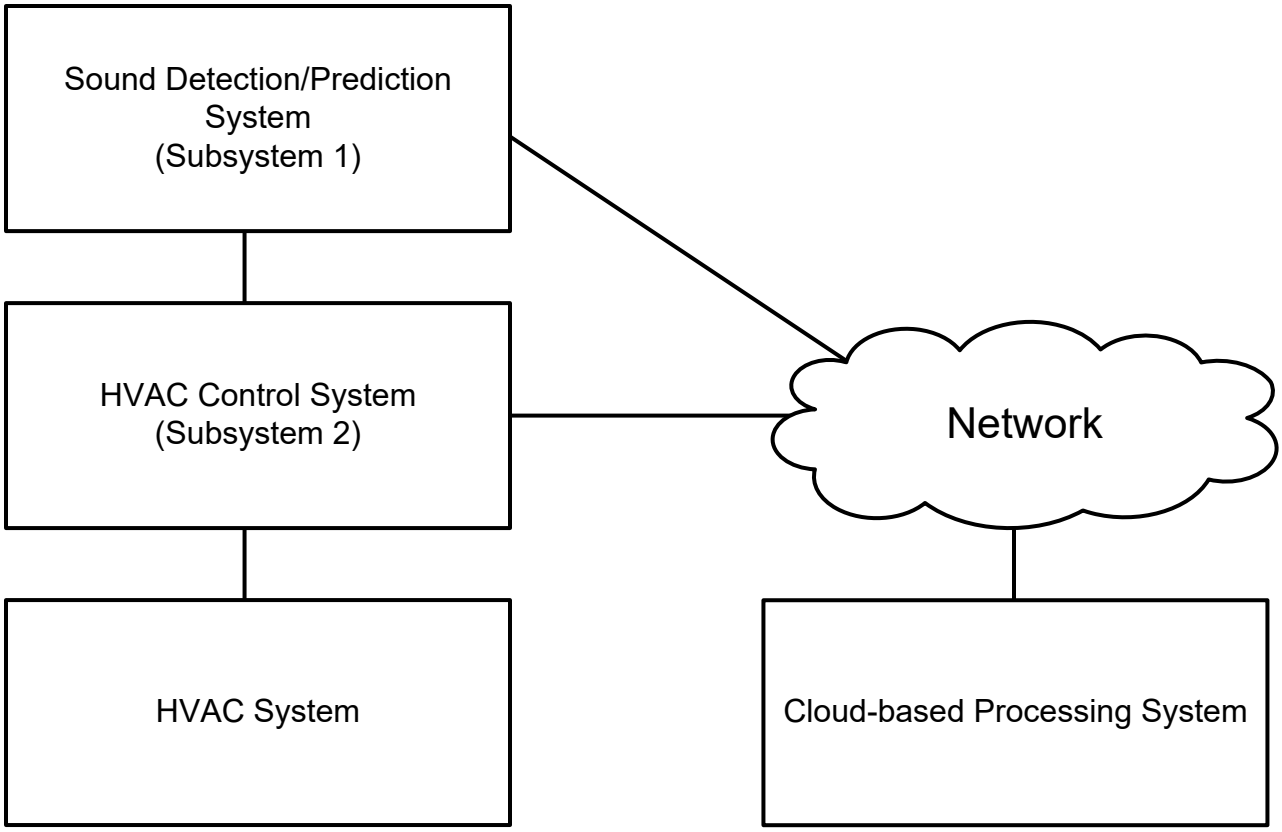

FIG. 1