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Method For Control Of A Cooling Fan In A Camera Recording System For Reduced Vibration

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METHOD FOR CONTROL OF A COOLING FAN IN A CAMERA RECORDING SYSTEM FOR REDUCED VIBRATION

ABSTRACT

A system and method are disclosed for reducing vibration from a camera cooling fan and thereby preserving high image quality. The system uses one or more accelerometers to provide feedback on vibration intensity and frequency that are used as input to control the fan. The fan may be switched at variable speed by a controller receiving inputs from a temperature sensor. The accelerometer(s) would measure the vibration in the camera structure at important locations such as the camera lens that would be sent to a computer or processor connected to the fan controller. The system would extract the vibration characteristics to identify speeds at which vibration is at a minimum. If the camera were too hot, the fan control loop could speed the fan up and find a local vibration minimum that would still keep the camera cool. The system uses inexpensive sensor inputs to improve image quality in cameras.

BACKGROUND

High end camera equipment (especially cameras used for video recording) produce significant amounts of heat, and almost universally use cooling fans to help move the heat out to the environment and cool the cameras. However, fans introduce both vibration and noise during operation. In general, the more heat the equipment needs to get rid of, the faster the fan needs to spin in order to cool the equipment. The faster the fan spins, the more vibration it tends to produce. The fan vibration takes the form of a generalized type of oscillating vibration known as a rotating unbalance. For many types of cameras, the vibration from the fan can be a significant issue. For example, camera systems with a very high angular resolution such as video cameras with zoom or microscope cameras are susceptible to motion blur from the vibration that can be imparted by the rotating fan. This adversely affects the image quality of these camera systems. This situation is significantly worsened if the fan is operated at or near one of the resonant peaks of the mechanical structure camera system. At resonance, the small vibration input from the fan can be amplified to a large displacement vibration across the structure, having a significant negative effect on the camera system imagery.

DESCRIPTION

A system and method are disclosed for reducing vibration from camera cooling fans and to preserve high image quality. The system as illustrated in FIG. 1 uses one or more accelerometers to provide feedback on vibration intensity and frequency to use as an input on a control loop for one or more fans. The fans may be switched or operated at variable speed by a controller receiving inputs from a temperature sensor. The accelerometer(s) would measure the vibration in the camera structure or at important locations such as the camera lens. This acceleration information would be sent to a computer or processor that is connected to the fan controller, which could extract the intensity and frequency components of the vibration. Based on the intensity of the vibration compared to a set threshold, the control loop could decrease (or increase, for reasons explained below) the fan speed. According to the rotating unbalance equations, the vibration can be minimized by either increasing or decreasing the speed of the fan as compared to the resonance. For example, if the fan speed was increasing to provide additional cooling, and the accelerometer was detecting a steep ramp in the displacement or velocity of the vibration, it would indicate that there was a structural resonance. Rather than continuing to monotonically increase the fan speed and excite the resonance, the fan controller would notch out the frequencies and skip them, thus preventing the high vibration associated with exciting a structure at resonance.

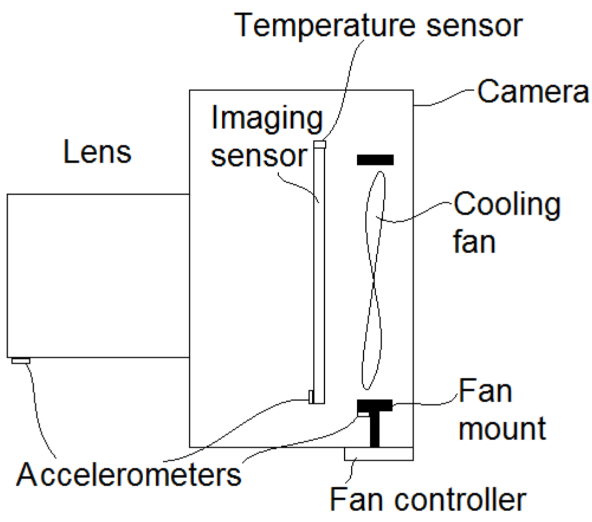

FIG. 1: System for controlling camera cooling fan to reduce vibration

The method could also make use of the pre-programmed and/or computed information to influence the operation of the fans. Pre-programmed information is defined as important derived frequencies or camera characteristics that are affected by vibration which are physical properties of the system and do not change. Some examples are the read-out rate of the sensor, the line delay, focal length, angular resolution, or even the natural frequency of electrical contacts in the system. Computed information is information that depends on current conditions that could affect image quality, such as thermal conditions, exposure time, lens speed, subject distance, or frame rate. For example, the motion blur in imagery due to translation is related to the velocity of the vibration multiplied by the exposure length. The method envisages ensuring that the blur is smaller than the circle of confusion of the camera, making it undetectable in the resultant imagery. The circle of confusion is based on a number of static pre-programmed parameters of the camera. The accelerometer information could be used by the computer to determine the velocity of the vibration, and then that number could be compared to the information from the camera regarding exposure length. If this calculated value is less than the pre-computed circle of confusion parameter and the camera was being adequately cooled by the fan, the fan control loop would not make any modifications. If the calculated value were larger than the circle of confusion, the fan control loop would adjust the speed of the fan to decrease the velocity of the vibration.

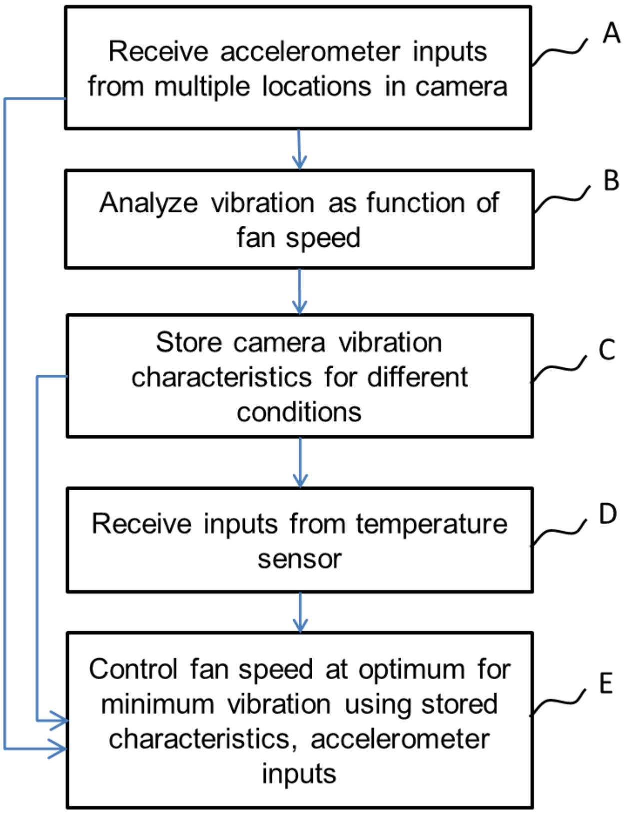

FIG. 2: Method of reducing vibration due to camera cooling fan

Similarly, if the camera were too hot, the fan control loop could speed the fan up and find a local vibration minimum that would still keep the camera cool. Another example would be that vibration at the same frequency as the sensor readout speed could result in non-blur visual artifacts, such as aliasing. In this case, the fan controller would be receiving speed (RPM) feedback from the fan and would notch that frequency so that the fan would never spin at that frequency and would accelerate past the sensitive frequency as quickly as possible. There are many combinations of accelerometer, fan speed, pre-programmed parameters, and computed camera parameters that yield similar calculated sensitivities and frequencies to avoid. Further, there can be multiple resonances in the structure and multiple vibration harmonics from the fans, so this would be a non-deterministic problem from a theoretical approach. Depending on how or where the camera is mounted, the resonances of the structure could completely change. The inclusion of one or more accelerometers measures the practical effect rather than the theoretical effect. There would be numerous local minima in the vibration intensity at various frequencies and that could only be determined by utilizing the feedback from the accelerometers. The interplay of these effects is so complex that only measuring the actual output through accelerometers would be able to provide a simple solution. The system disclosed would be able to take into account all of these in operation of the fan control system. The various sensitivities and frequencies could also be weighted by the control system to help reach desirable operating points.

The system and method proposed allows for usage of inexpensive and simple hardware (in this case, accelerometers) in a novel way that allows control of a complicated set of weighted parameters relating to components of the camera assembly, to minimize vibrations and improve image quality. In an alternative implementation, the system could use an optical sensor to detect image blurring and control fan speed to improve image quality.