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Techniques for Automatically Determining a Time-Lapse Frame Rate

Abstract:

This publication describes techniques for automatically determining a frame rate for use in time-lapse photography. A tracking box containing pixels corresponding to an object that is moving within a field of view of an imaging device is first determined, either autonomously or based on user input. Successive frames are then taken at an initial frame rate, and the tracking box is identified in each of the frames. A pixel-change ratio is then calculated that represents a percentage of the pixels within the tracking box that moved and/or changed between the successive frames. The frame rate for the time-lapse is then determined based on the pixel-change ratio.

Keywords:

time-lapse, time lapse, photo, photography, video, videography, frame rate, frames per second, FPS, change ratio, change percentage, image, scene, speed, motion detection

Background:

Time-lapse photography is a technique through which a series of images of a scene are captured at a particular frame rate and are displayed at a higher frame rate. In aspects, a user decides a frame rate to use for a time-lapse (*e.g.*, 12 frames per second (FPS) (also referred to as 2x speed based on a 24 FPS standard), 4.8 FPS (5x), 2.4 FPS (10x), 0.8 FPS (30x), 0.2 FPS (120x)). Even with suggestions based on a subject matter of the time-lapse, a selected frame rate is often not optimal. For example, a user may select a frame rate that corresponds to moving clouds; however, that frame rate is based on an average speed of moving clouds. If the subject matter

clouds are moving faster or slower than the average speed of moving clouds, the results will not be optimal. As such, it is desirable to have a device automatically determine an optimal frame rate for a time-lapse.

Description:

This publication describes techniques for automatically determining a frame rate for use in time-lapse photography. The techniques may be implemented within an imaging device (*e.g.*, digital camera of a smartphone, digital camera) and involve selecting a moving object, creating a tracking box around the object, calculating an amount of the tracking box that changed between successive frames at an initial frame rate, and determining a final frame rate for the time-lapse (referred to as “the frame rate” or “the frame rate for the time-lapse” below) based on the amount of the tracking box that changed between the frames at the initial frame rate.

Stage 1: Object Selection and Tracking Box Creation

First, a moving object in a scene (*e.g.*, a field of view of a camera of an imaging device) is selected. The object selection may be based on a user input selecting or setting a focus on a particular moving object of interest for the time-lapse, or the object selection may be performed automatically (*e.g.*, by an object-detection framework).

Once the object is selected, a tracking box around the pixels corresponding to the selected object is created. The tracking box generally encompasses the object of interest with minimal extra area. Although it is referred to as a tracking box, the shape of the tracking region is arbitrary and may comprise a circle, polygon, freeform shape, etc.

Stage 2: Pixel-Change Ratio Determination

Next, a pixel-change ratio is calculated that represents a percentage of pixels within the tracking box that have changed between successive frames at an initial frame rate. The successive frames correspond to an initial frame and a subsequent frame that occur after a period that corresponds to the initial frame rate. For example, if the initial frame rate is 12 FPS, then the period would be 1/12 of a second, thus, the subsequent frame occurs 1/12 of a second after the initial frame. Standard playback speed is 24 FPS; thus, the initial frame rate is generally the fastest frame rate that would be considered a time-lapse (e.g., 12 FPS (2x)). While the disclosed techniques start with the fastest acceptable frame rate and then calculate a final (slower) frame rate for the time-lapse, the techniques can easily be adapted to start at an arbitrary frame rate and calculate a faster (or slower) final frame rate.

In order to determine the pixel-change ratio, a pixel-change value representing a number of pixels that have changed between the frames is first calculated. The calculation may be performed in any number of ways, for example, via a centroid tracking algorithm, a boundary tracking algorithm, a frame comparison algorithm, a pixel comparison algorithm, etc. In general, one or more of the following situations will occur between the frames:

Situation 1) The object has generally not changed, but it has moved relative to the device, as shown in Figures 1 and 2 below.



Figure 1: Tracking box in the initial frame.



Figure 2: Tracking box in the subsequent frame.

In this case, the pixel-change value is based on how many pixels are shared between the tracking boxes of the two frames. An overlay of the two tracking boxes is shown in Figure 3 below.



Figure 3: Overlay of the tracking boxes of the frames.

In the example above, only a portion of the hood and the front right tire of the car are shared between the frames, thus, a number of pixels that are not in this overlap area are considered to be the pixel-change value.

Situation 2) The object has generally not moved, but it has changed shape, size, or color, as shown in Figures 4 and 5 below.



Figure 4: Tracking box in the initial frame.

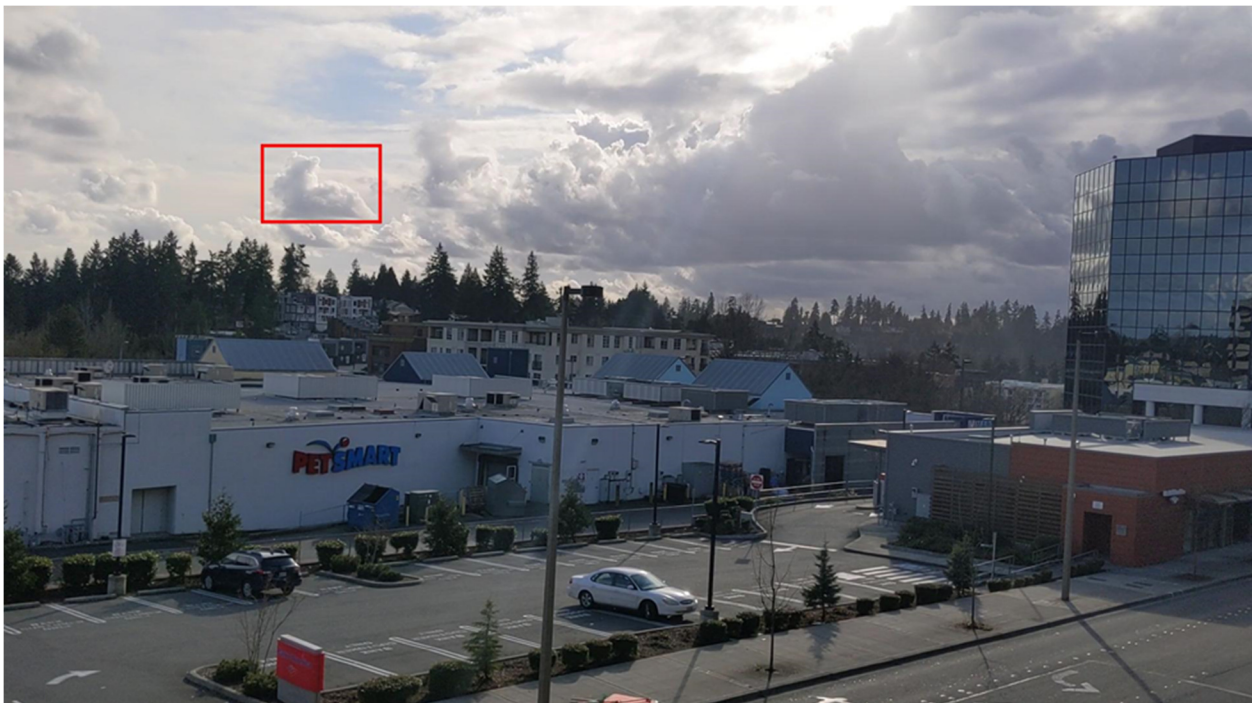


Figure 5: Tracking box in the subsequent frame.

In this case, the pixel-change value is based on how many pixels have changed within the tracking box between the two frames. A representation of the changed pixels between the frames is shown in Figure 6 below.

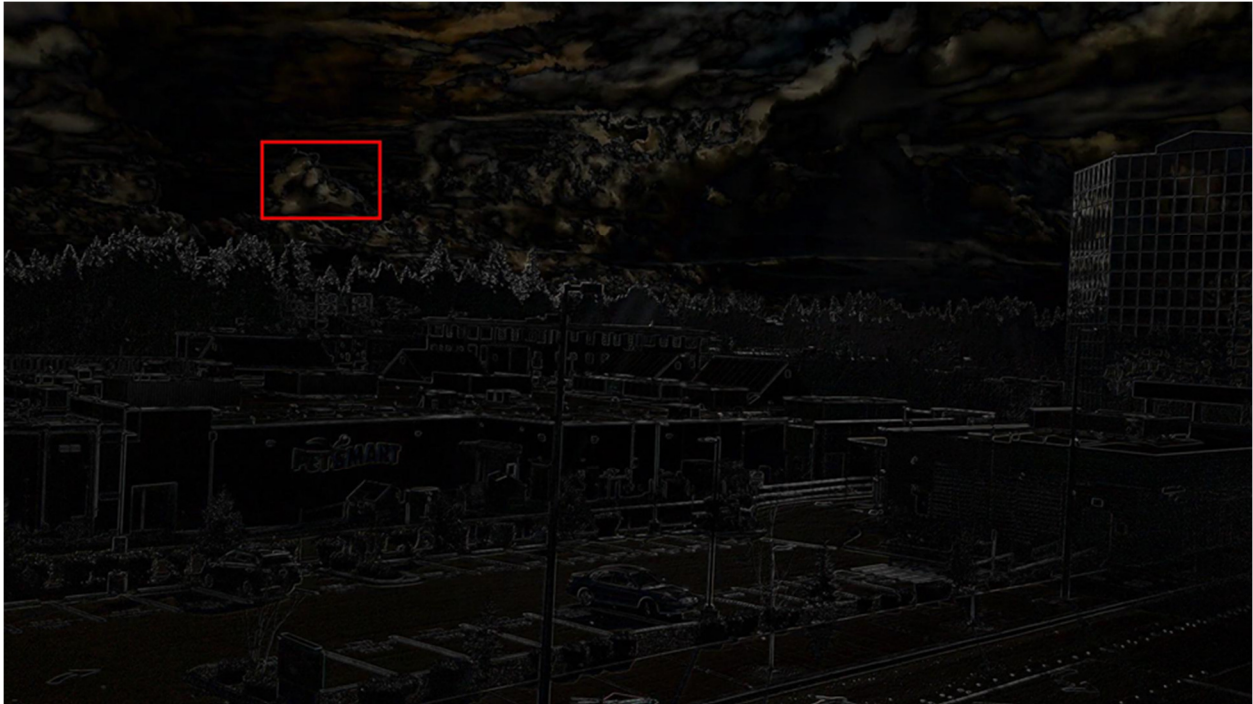


Figure 6: Changed pixels between the frames.

In this case, the pixel-change value is the number of changed pixels within the tracking box area.

In either of the Situations (or a combination of the two), the pixel-change value is compared to a total number of pixels within the tracking box (*e.g.*, the size of the tracking box), to determine the pixel-change ratio. In some cases, an average of the total numbers of pixels of each of the respective tracking boxes may be used if the size of the tracking box changed between frames.

Stage 3: Frame Rate Determination

Once the pixel-change ratio has been calculated, the pixel-change ratio is compared to a threshold value. The threshold value may be variable and is based on generalizations of what is considered optimal for a time-lapse. For example, the threshold value may be based on an idea that an object in a time-lapse should change or move completely (*e.g.*, have a 100% pixel-change

ratio) in one second. Based on a standard 24 FPS video, this corresponds to a 4.2% pixel-change ratio for optimal results. For simplicity, a rounded value (*e.g.*, 4%, 5%) may be used.

If the pixel-change ratio at the initial frame rate (*e.g.*, 12 FPS) is at or above the threshold value, then the initial frame rate is selected as the frame rate for the time-lapse.

If the pixel-change ratio at the initial frame rate is below the threshold value, then Stage 2 is repeated for additional subsequent frames. In other words, the pixel-change ratio between the initial frame and the additional subsequent frames is calculated until the pixel-change ratio between the initial frame and an additional subsequent frame meets the threshold value.

There are two ways of calculating the pixel-change ratios between the initial frame and the additional subsequent frames: Option 1 uses a comparison of the initial frame and each of the additional subsequent frames to calculate the pixel-change ratio, or Option 2 calculates pixel-change ratios between each additional frame pair and aggregates the pixel-change ratios until the threshold is reached. There may be a case where the object is changing between each new subsequent frame pair but the pixel-change ratio between the initial frame and each additional subsequent frame is still less than the threshold. This would cause the threshold to never be reached. Accordingly, Option 2 accounts for such a situation by always passing the threshold value.

Another way to determine an additional subsequent frame that meets the threshold value is to adjust the frame rate for the additional subsequent frames based on the pixel-change ratio between the first two frames. Under the assumption that the object is moving at a constant speed, a frame rate can be estimated that will result in the next subsequent frame passing the threshold. For example, if the pixel-change ratio for the first two frames is 1.5%, then it may be estimated that the additional subsequent frame that will meet the 4% threshold value will occur at 1/6 of a

second after the last frame (if the first two frames were captured 1/12 of a second apart). By using this technique, at least one frame calculation can be saved.

Once an additional subsequent frame that reaches the threshold value has been identified, a time interval between the initial frame and the additional subsequent frame is determined. The inverse of the time interval is then chosen as the frame rate for the time-lapse video. For example, if it is determined that the time interval between the initial frame and an additional subsequent frame that met the threshold value is 0.5 seconds, then the frame rate for the time-lapse would be calculated as $1/0.5$, which is 2 FPS (12x).

In some implementations, Stages 2 and 3 are repeated over a time frame in order to get a more robust calculation of frame rate for the time-lapse video. For example, the process may be repeated ten times within the time frame, and an average of the ten calculated frame rates may then be used as the frame rate for the time-lapse video. The time frame may be selected based on a minimum frame rate for the imaging device. For example, if it is determined that one frame per minute (0.017 FPS) is the slowest selectable speed, then setting the time frame at one minute ensures that all situations with optimal frame rates up to one frame per minute are covered. If the threshold value has not been reached at the time frame, then the slowest selectable speed may be selected (*e.g.*, one frame per minute). There is no loss of data within the time frame, as frames are being collected at the initial (*e.g.*, the highest) frame rate.

The techniques described above may be implemented as part of a camera user interface or as part of a camera application of a device that includes an imager. For example, an “auto” button or user interface element may be included that causes the imaging device to calculate an optimal frame rate using the above techniques and capture a time-lapse using the optimal frame rate with minimal intervention from the user.

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