An Approach for Frame Rate conversion of a Video

Dr. H S Prasantha

Professor, E&CE department, Nitte Meenakshi Institute of Technology, Bangalore-64, Karnataka, India,
Corresponding Author: Dr. H S Prasantha

ABSTRACT: As Frame rate is the frequency at which an imaging device produces unique consecutive images called frames. Both video and photographic films capture a series of frames (still images) in rapid succession. For instance, the NTSCsystem delivers 29.97frames/s and PAL system delivers 25frames/s.Frame Rate Conversion algorithms are used in compression, video format conversion, quality enhancement, stereo vision, etc. The most popular application is format conversion. The difference in frame rates between film (generally 24 frames/s) and television (30 or 25 frames/s) meant that simply playing a film into a television camera would result in flickering when the film frame was changed in mid-field of the TV frame.Frame Rate Conversion makes the motion of objects smoother and therefore more pleasant for eyes. It allows slowing down the playback speed thus making the objects' movements more evident. In this paper we present an approach of converting the frame rate of a video by duplicating specific frames. Also, the recovery of the original video from the converted video is also performed.

KEYWORDS: Frame, Frame rate, Frame rate conversion, duplication

I. INTRODUCTION

In filmmaking, video production, animation, and related fields, a film frame or video frame is one of the many still images which compose the complete moving picture. The human eye and its brain interface, the human visual system, can process 10 to 12 separate images per second, perceiving them individually. The visual cortex holds onto one image for about one-fifteenth of a second, so if another image is received during that period an illusion of continuity is created, allowing a sequence of still images to give the impression of motion. When the moving picture is displayed, each frame is flashed on a screen for a short time (nowadays, usually 1/24, 1/25 or 1/30 of a second) and then immediately replaced by the next one. Persistence of vision blends the frames together, producing the illusion of a moving image. The frame is also sometimes used as a unit of time, so that a momentary event might be said to last six frames. The actual duration of each frame depends on the Frame rate of the system, which varies according to the video or film standard in use.

NEED FOR CONVERSION

Frame Rate Conversion algorithms are used in compression, video format conversion, quality enhancement, stereo vision, etc. The most popular application is format conversion. This is the case when FRC is used in order to convert the frame rate of video stream. It is needed for example in order to playback 50Hz video sequence using TV set with 100Hz frame rate. The difference in frame rates between film (generally 24 frames/s) and television (30 or 25 frames/s) meant that simply playing a film into a television camera would result in flickering when the film frame was changed in mid-field of the TV frame.

Judder is a real problem these days where 46 and 52-inch television sets have become common. The amount an object moves between frames physically on screen is now of such a magnitude that objects and backgrounds can no longer be classed as "clear". Letters cannot be read and looking at vertical objects like trees and lamp posts while the camera is panning sideways have even been known to cause headaches. The actual amount of motion blur needed to make 24 frames per second smooth eliminates every remnant of detail from the frames. Where adding the right amount of motion blur eliminates the uncomfortable side effects, it is more than often simply not done. It would also potentially remove the detail and clarity of background advertising. Many televisions now have an option to do some kind of frame interpolation such as adding a frame between two real frames to overcome this problem. Frame Rate Conversion makes the motion of objects smoother and therefore more pleasant for eyes. It allows slowing down the playback speed thus making the objects' movements more evident.

This paper intends to offer an overview of one among the many different algorithms used for Frame rate conversion. After the overview it briefly reflects on the methodology involved in increasing or decreasing the frame rate. This reflection is based on a set of criteria that we have identified for the conversion.

II.   METHODOLOGY

A. Up-Down conversion

In a situation where we have two different frame rates and need to convert one to match the other, there are two directions that we can go. Let us say that we have footage shot at 24fps and 30fps. If we convert the 24fps footage up to 30fps, the full 24 frames will be used and an additional 6 frames will be created, for a total of 30. The additional 6 frames will be based on the information contained in the original 24 frames therefore no information is lost. This method of converting the frame rate is called Up Conversion.

The other way to go would be to take the video shot at 30 frames and reduce it down to 24 frames also known as Down Conversion. This would generally not be the way to do frame rate conversions because, if 30 frames are to be reduced to 24, 6 frames will have to be removed and these 6 frames may contain important amount of information, particularly regarding motion. Doing frame rate conversions in this manner will produce stutter in the video, though not observed by the human eye when the difference in frame rates is minimum. Therefore, up conversion is always preferred to down conversion.
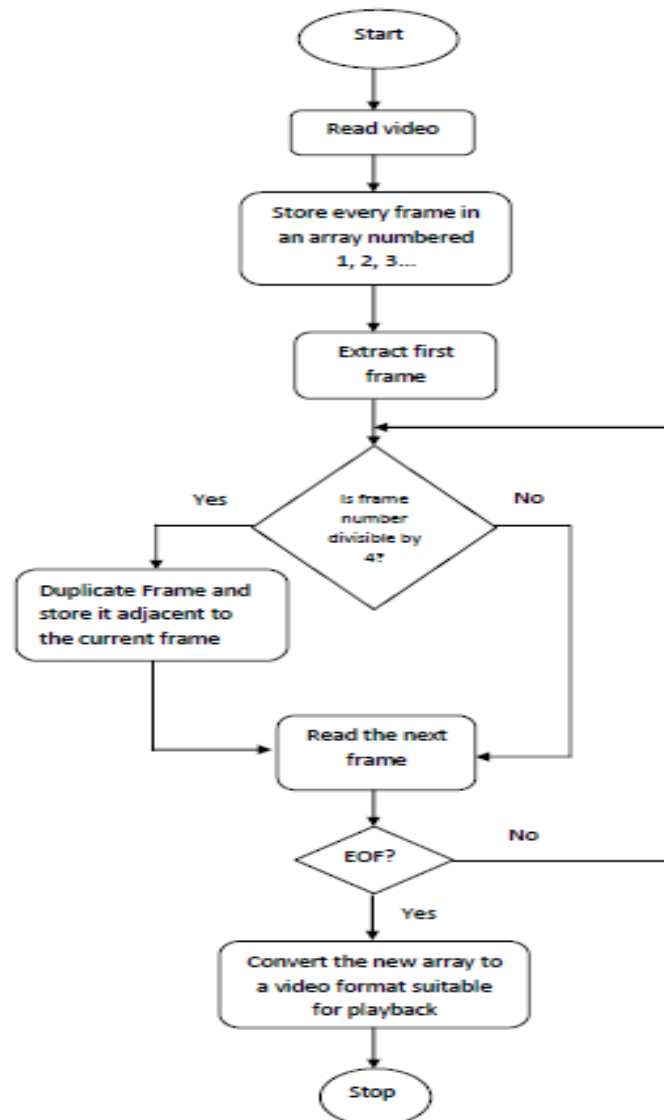

Figure 1: The methodology of the proposed work

III. IMPLEMENTATION DETAILS

The experiments are conducted in a simulation environment using MATLAB tool and the different cases are presented.

Example: To convert a video which is of 24 frames/s to 30 frames/s, we have chosen the first 500 frames of thevideo with the order of frames as follows
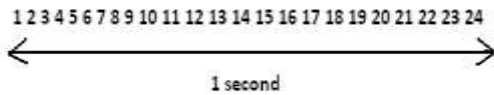
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

⟵────────────────────────────⟶

1 second

Figure 1: 24 FPS

Every fourth frame of this video was then duplicated to generate the following sequence

1 2 3 4 4 5 6 7 8 8 9 10 11 12 12 13 14 15 16 16 17 18 19 20 20 21 22 23 24 24
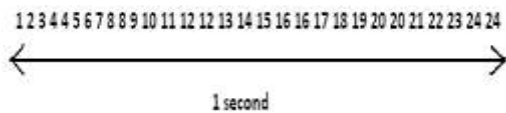
⟵────────────────────────────⟶

1 second

Figure 2: 30 FPS

The frame rate of the video is now effectively increased to 30fps in contrast to 24 as the input frame rate. Up Conversion is thus achieved.To retrieve the original video of 24fps from the 30fps video generated above, every fourth frame of the video is removed to generate the same sequence.

The algorithm uses the selection of new frame is repetition of fourth frame only

Choosing frames based on Mean Square Error (MSE)

In the algorithm discussed, the fourth frame was chosen at a random. The choice of the frame to be duplicated can also be on the mean square error criterion. This is done as follows:

- Divide the total number of frames of the video into groups of four
- Find the mean square error between the first and the second frame
- Mean square error between the second and third, third and fourth and fourth and fifth frame is also calculated
- The frame which gives the highest MSE with its adjacent frame, is identified and that frame is duplicated

Repeat the above procedure for all the other framesThis algorithm is based on the fact that higher the MSE between two frames, higher is the te of change of information. Hence, the frame which contains the greatest amount of information among the four frames is the frame that is duplicated. On doing this, we are ensuring that the quality of the video is enhanced as the key frame of the video will be the one which is duplicated thus giving more information.

The following table gives the calculated MSE values based on the equation

$$\frac{\sum_{M,N}[I1(m.n) - I2(m,n)]^2}{M * N}$$

Where, I1 and I2 are the images and M and N are the number of rows and columns of the input images respectively.

The table 1 shows the MSE values of the first 10 frames of the video. According to the method explained above considering only first 20 frames, the 1st,7th,9th,$16^{th}$and 17th frames of the 24fps video are duplicated based on the MSE values between them.

Table1: MSE values of frames

FRAMES	MSE VALUES
1st	386.7455
2nd	355.4670
3rd	306.807
4th	286.5560
5th	269.5365
6th	285.8037
7th	302.4989
8th	289.5456
9th	137.9050
10th	126.9457

We choose the frame with more information based on MSE value between the frames and duplicate them to obtain a 30 fps video. Thus, this method is found to be more adaptive. Frames 1 and 2 should be repeated as per table 1.

IV. RESULTS AND DISCUSSIONS

Frame 1	Frame 2	Frame 3

Frame 4	Frame 5	Frame 6

Frame 7   Frame 8

Figure 4: Input video (Displaying 8 frames to discuss)

Frames of 30fps video of duplicating the 4th frame

Frame 1	Frame 2	Frame 3

Frame 4

Frame 4 a

Frame 5

Frame 6

Frame 7

Frame 8

Frame 8 a

Figure 5: Total 10 frames displaying from 8 frames with repetition of every fourth frame

Frame 1

Frame 1 a

Frame 2

Frame 2 a

Frame 3

Frame 4

Frame 5

Frame 6

Frame 7

Frame 8

Figure 6: Frames of video duplicating using MSE method

In both cases, on performing the up conversion, the video was observed to be playing at a slower rate in terms of the time that was taken to view 500 frames. This can be accounted for by the addition of the duplicated frames. There was no visually perceivable difference observed in the quality of the video after up conversion or down conversion. Since in both the algorithms, we have

retrieved the original video from the converted video (with the duplicated frames), there will be no loss of information on down conversion and hence it was perceptually observed to be the same as that of the initial video of 24 frames.It can be inferred that quality degradation is observable in cases where the difference in the frame rates is large where blurring may occur. A significant increase in the size of the video file is also observed which can be accounted for by the duplicated frames.

The drawback observed in the second algorithm which was based on the MSE was that the last frame taken has no frame to be compared with and hence the mean square error cannot be calculated. Therefore, it can never be duplicated. In cases where the last frame has the most amount of information, this can be a serious drawback and can cause significant degradation in the amount of the information.

V. CONCLUSION

Frame rate, also known as frame frequency is the frequency at which an imaging device produces unique consecutive images called frames. Shooting at 24fps would be best for special scenes to show detail for example. It has more trouble with fast motion than other, higher frame rates, sometimes showing a "strobe" or "choppy" motion. 24fps would not look good when shooting fast moving subjects, like in sports for example. Not all video editing programs support 24fps, like consumer-based non-linear editing systems. 30fps is very common and will give excellent imagery. By changing the frame rate to 30fps to 24fps, the duration of the video is reduced. A faster frame rate, allows for faster action to be captured without "motion blurring" but it also makes the video more affected by camera shake. The quality of each frame is also reduced.

This paper gives an idea about one among the many algorithms which are available for frame rate conversion. Other methods such as duplicating either even or odd fields of an interlaced video or manipulating with only certain frames to achieve a variable frame rate are also available and can be considered as an extension to this project.

Frame rate conversion is observed as a necessity in applications such as Smart-phones, PDAs and other mobile devices, LCD and plasma displays, 3D displays, Video conferencing, Video editing (slow motion effect) and so on.

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