# A11 – Basic Video Processing

## Introduction

Video is a series of still images shown in rapid succession such that an impression of movement is perceived by an observer. All image processing techniques we've learned so far may be applied on image frames of a video. The advantage of video is that it allows us access to another physical dimension, time. Thus, under some simplifying assumptions, the dynamics and kinematics of a system can be extracted from video.

Each digital video has a ***frame rate*** for image capture expressed as ***fps*** or "frames per second". The inverse of the frame rate gives us the time interval, $\Delta t$, between frames. For example, consumer video is around 30fps or 30Hz. This means 1/30s or 33ms is the time interval between successive image frames of video.

Care must be taken when measuring kinematic variables using video. According to the Nyquist Criterion, we can only measure time-varying signals without aliasing if the highest sinusoidal frequency present in that signal is $1/(2\Delta t)$ (or 1/2 fps) or lower. This means for consumer video-based motion analysis, we can only capture repetitive motion reliably if its frequency is 15Hz or less.

The way we will process video for now is offline, that is by converting a video clip into an image sequence. Once stored as individual images, you may then extract position, shape or area using image processing technique looping through the image sequence to get the time variation of your variables of interest.

Some assumptions must be met to simplify processing:

1. Camera should be stationary – better if it is on a tripod or on a steady platform.
2. The object should be single coloured and background should be as plain as possible – better if the background is plain colored, not the same color as the object being tracked, and that there are no other moving objects in the background.

3. There should be a reference length (ruler, tape measure, or object with known length) in the same plane as the motion of an object. The object to be tracked is in 3D space while image is 2D space. The loss of a third spatial dimensional will not affect your measurement if the object movement is only along a plane. Therefore, the video camera should be set up such that its image plane is parallel to the plane of the motion of the object.
4. The lighting of the scene should be even to ensure successful segmentation.

## Materials

Videocam, ruler or measuring tape, video conversion software (freeware), object (single-colored) to be tracked.

## Procedure

1. Set up a kinematic experiment with your colored object such that the variable that you want to derive can analytically be verified. For example, finding the acceleration due to gravity is easiest to validate. You can throw a tennis ball in the air, or drop it from a height, or use a pendulum (just make sure the oscillation is less than 15Hz!). Place a reference length on the same plane as where the colored object will move.
2. Capture two or three 5-second takes of your kinematic event using a video camera to be provided.
3. Convert the video clips into image sequences using any of the 5 suggested ways discussed in this webpage : https://www.raymond.cc/blog/extract-video-frames-to-images-using-vlc-media-player/
4. Process the frames to extract significant variables. For example, you might want to capture the position of the ball, use color segmentation to determine the probability of the ball's position. You can clean the blobs using morphological operations. Then compute the centroid of the backprojected image to get an estimate of the ball's X-Y position.
5. Plot extracted variables against time and compute the kinematic constants you set out to find. Compare your results with the analytical values.