Animations in MATLAB

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https://courses.washington.edu/danielab/labwiki/index.php?title=Making_animations_in_MATLAB

Easiest implementation:
`FOR` - loop creates updated figures for each frame of the final movie

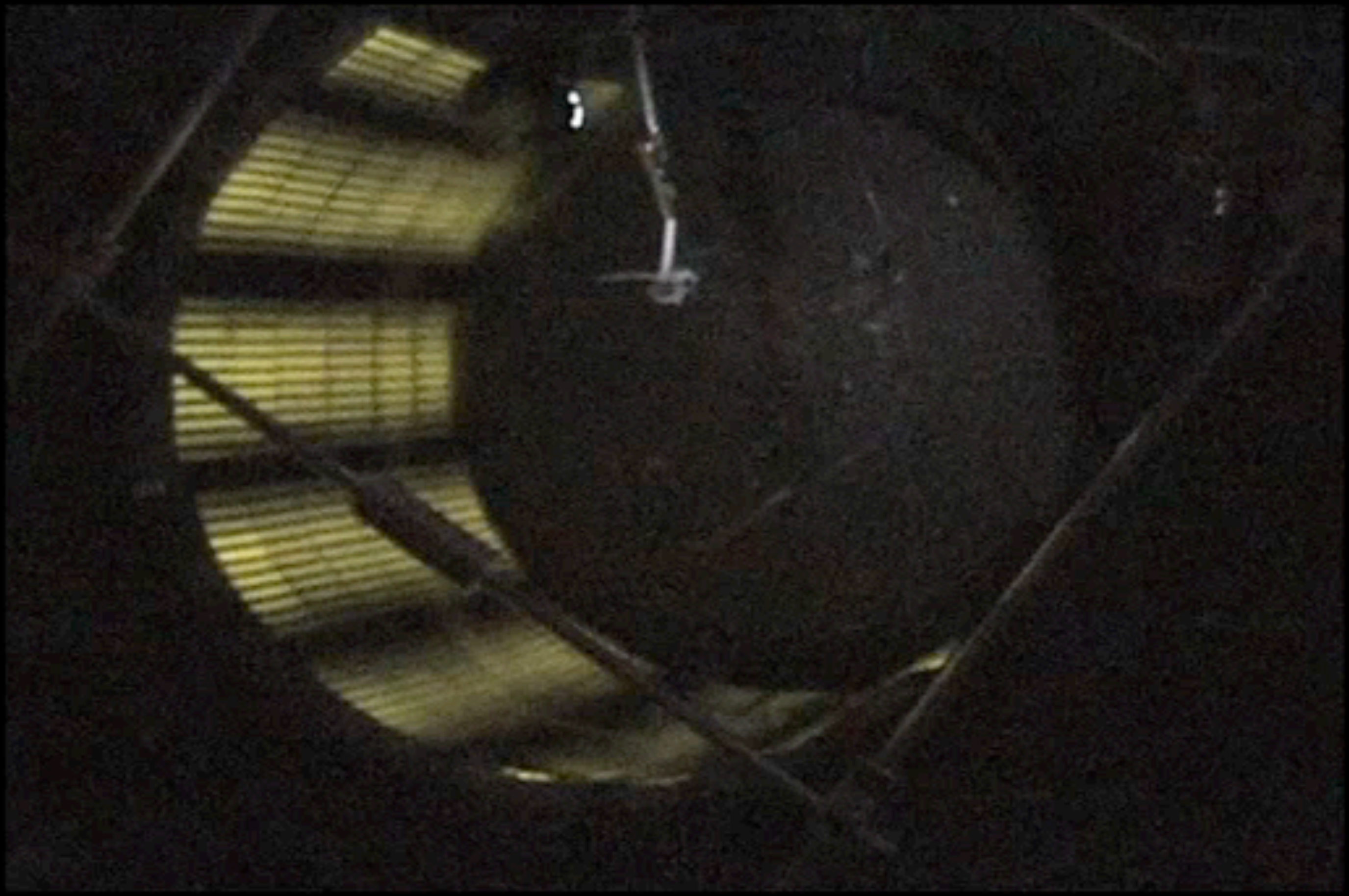
From Mathworks docs:

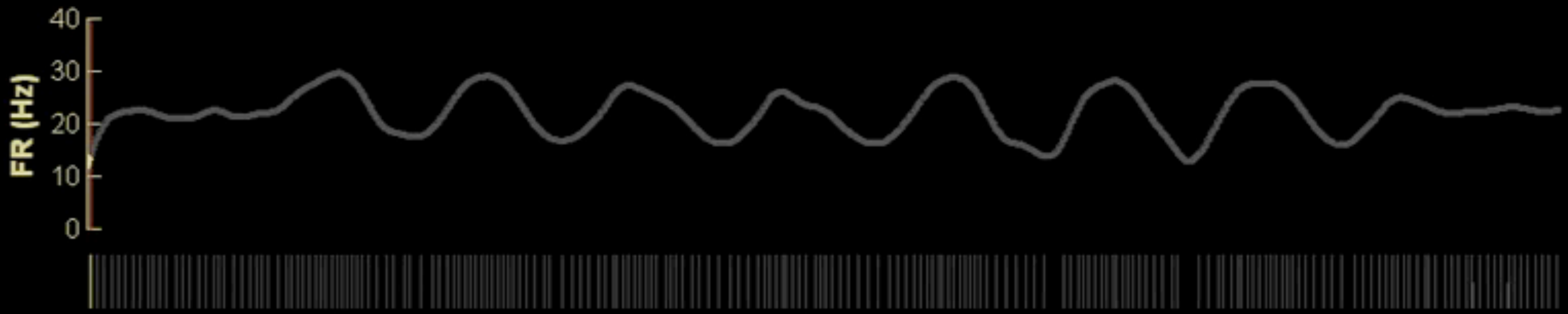
You can create animated sequences with MATLAB graphics in three different ways:

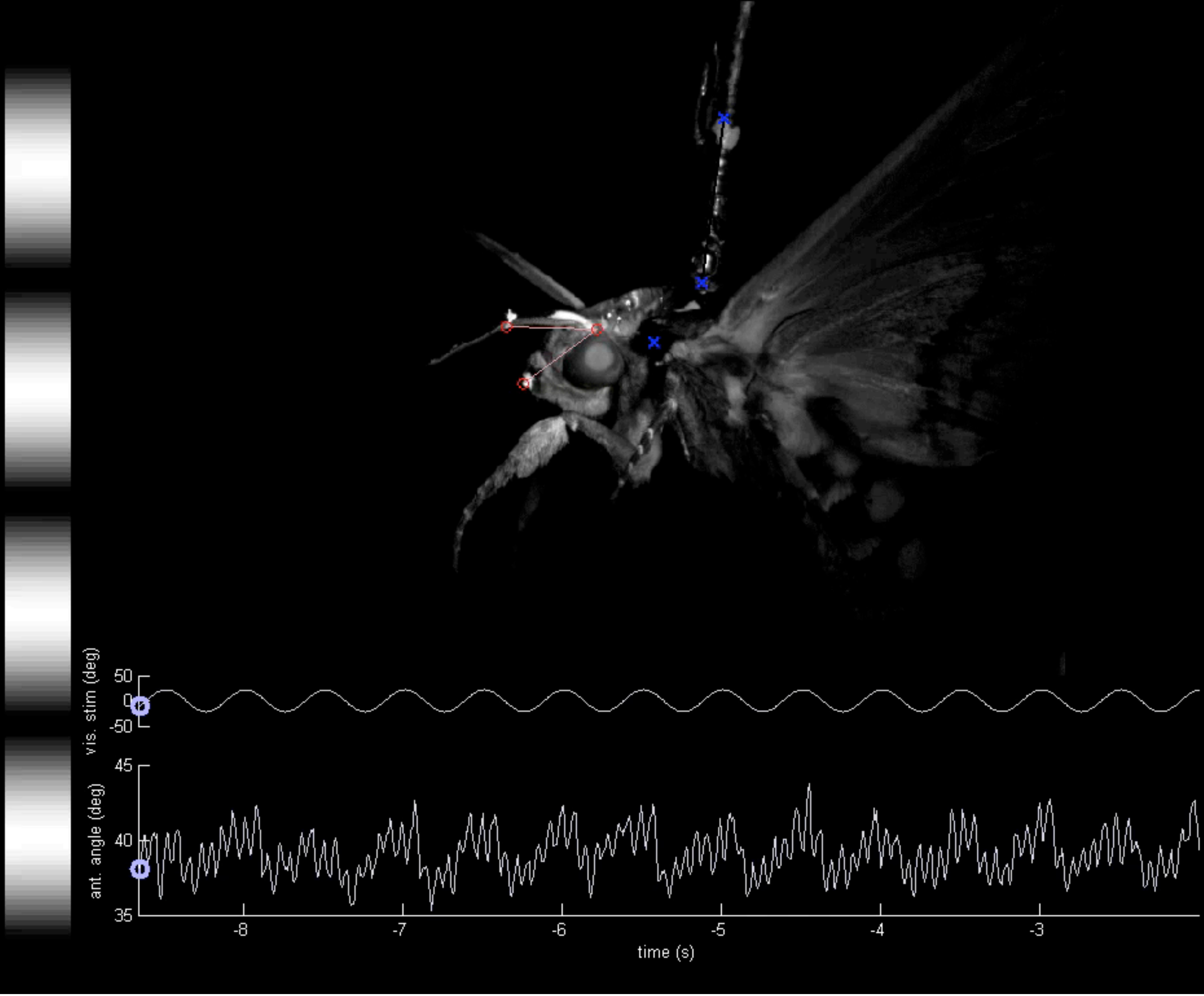
- **Save a number of different pictures and play them back as a movie.**
- Continually erase and redraw the objects on the screen, making incremental changes with each redraw.
- Redefine the `XData`, `YData`, `ZData`, and/or `CData` plot object properties, optionally linking them to data sources (workspace variables) and updating the properties via calls to `refreshdata`.

I'll show you the recipe that works for me, but there are many ways to achieve animated bliss

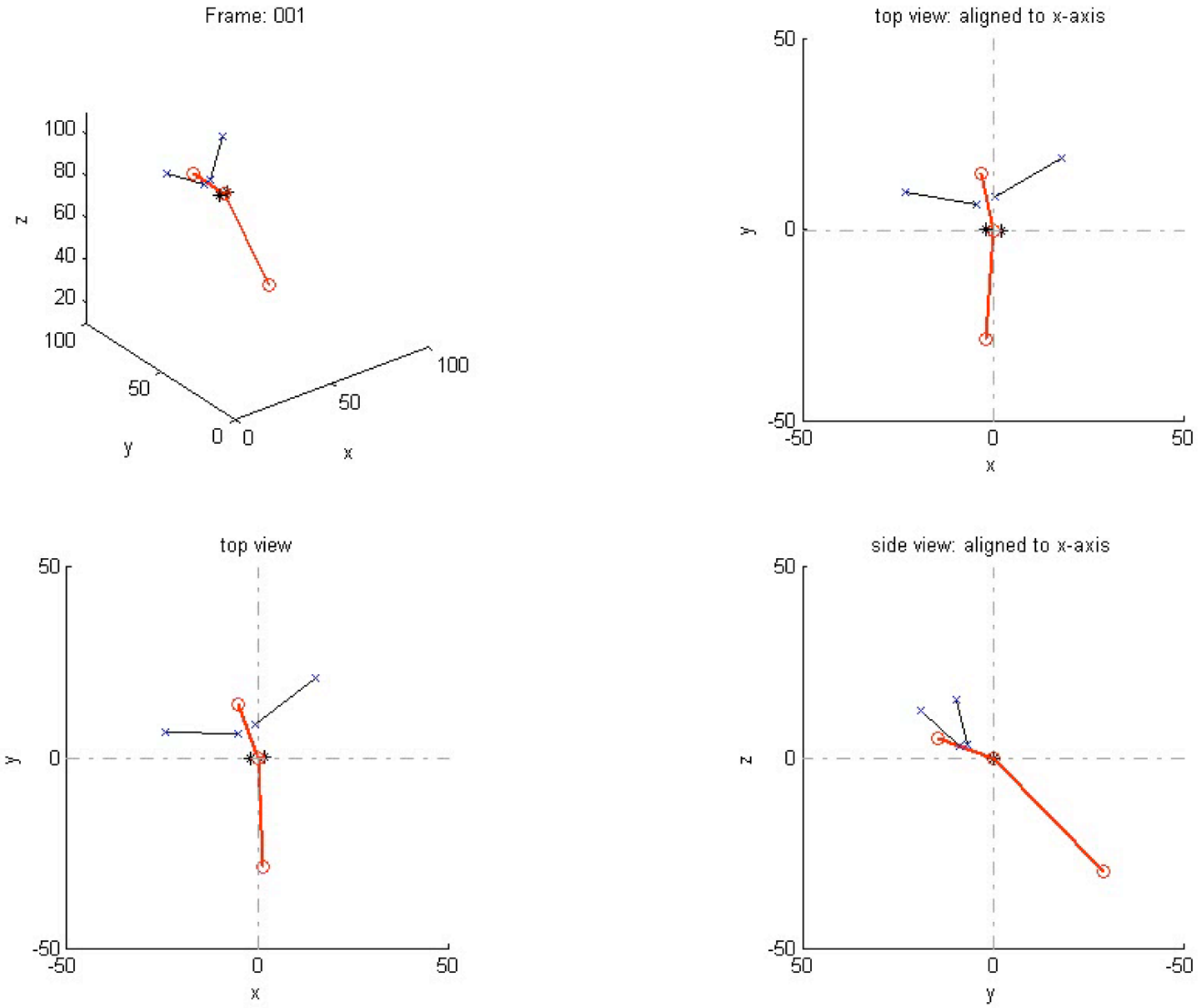
Example movie:






50
0
-50
vis. stim (deg)
45
40
35
ant. angle (deg)
-8
-7
-6
-5
-4
-3
time (s)

Digitized points (3D) of a hovering moth



Step-by-step example of how to create a multi-axes animation

Topic covered:

- creating an animation from a parametric equation
- saving the animation as an image sequence (TIFF stack)
- planning and creating a multi-axes figure
    - set up the `FOR` loop
    - draw axes for images and data graphs
    - load sequential images from TIFF stack
    - update information for each frame
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Creating an animation from a parametric equation: setting up the path a dot should move along

```
%% create data for our animation: a dot moving along a path
% Our aim is to make a circle move around an image along a specified path.
% First, we'll create that path (xpos and ypos)

revolution_no = 5;          % how often around the circle
ang_resolution = 40;        % how many points (i.e. frames) per circle
da = 2*pi/ang_resolution;   % delta angle

t = 0:da:revolution_no*2*pi;             % time steps

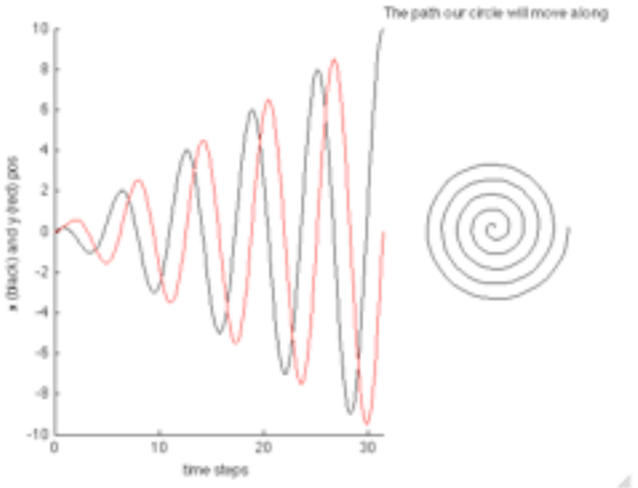
% why not a spiral:
pathradius = linspace(0,10,length(t));  % path radius increases each dt
xpos = pathradius.*cos(t);
ypos = pathradius.*sin(t);

% show what we have so far:
figure(1);
subplot(1,3,1:2)
plot(t,xpos, '-k'); hold on;
plot(t,ypos, '-r');
set(gca, 'XLim', [0 max(t)]); box off;
xlabel('time steps');  ylabel('x (black) and y (red) pos')

subplot(1,3,3)
plot(xpos,ypos,'k'); axis equal; axis off;
title('The path our circle will move along');

% We now want to use these x-y coordinates to place a cirle on an image.
% Each iteration, we want the position to be updated so that it appears as
% if the circle moved around the specified path.
% In addition, we want the circle diameter to change as it goes along.

circlesize = linspace(0.2,2, length(t)); % circle size increases linearly
```



Plotting a circle that follows our path equation

helper function

```
%% Test the moving circle
% We'll now plot a circle for each time steps, according to the path and
% size specifications above. I created a separate function to create the
% circle, called 'plotfilledcircle'.

axlim = 15;
figure;
for c = 1:length(t)

    ph=plotfilledcircle(circlesize(c), [xpos(c) ypos(c)]);

    % we need to set the axes to an appropriate limit, otherwise they'll
    % resize to always show the full circle:
    axis([-axlim axlim -axlim axlim]);
    axis square;
    % create a counter that updates each iteration:
    titlestr = sprintf('Frame: %03d', c);
    title(titlestr);

    pause(0.05); % pause a bit to see animation
end
```

Function to draw a circle

helper function

```
function ph = plotfilledcircle(circle_radius,circlecenter, fcol)
%
% plotfilledcircle(circle_radius,circlecenter, fcol)
%
% Function to plot a filled circle with radius 'circle_radius'
% 'circlecenter' ... center location [0 0] is default
% 'fcol' is optional and defines the face color (black default)
%
% Armin H 2011

if nargin < 2
    circlecenter = [0 0];
end
if nargin < 3
    fcol = [0 0 0];
end

theta = linspace(0,2*pi,100); % 100 points between 0 and 2pi
x = circle_radius*cos(theta) + circlecenter(1);
y = circle_radius*sin(theta) + circlecenter(2);
ph = fill(x, y, 'k');

set(ph, 'FaceColor', fcol);
box off;  axis equal;

end
```

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Saving the animation as an image sequence (TIFF stack):

`imwrite()` function writes frames captured with `frame2im()` to a file

```
axlim = 15;
figure;
for c = 1:length(t)
    fprintf('Frame: %03d\n', c); % display counter

    ph=plotfilledcircle(circlesize(c), [xpos(c) ypos(c)]); % plot circle
    axis off;
    % we need to set the axes to an appropriate limit, otherwise they'll
    % resize to always show the full circle:
    axis([-axlim axlim -axlim axlim]);
    axis square;

    % We'll save this animation as a tiff stack, so we can load it
    % back later for our grand finale
    currentframe = frame2im(getframe(gcf)); % convert fig into image data
    currentframe = im2bw(currentframe,0.4); % make it binary to save space
    if c == 1
        imwrite(currentframe, 'tiffstack.tiff', 'WriteMode', 'overwrite');
    else
        imwrite(currentframe, 'tiffstack.tiff', 'WriteMode', 'append');
    end

    pause(0.05); % pause a bit to see animation
end
```

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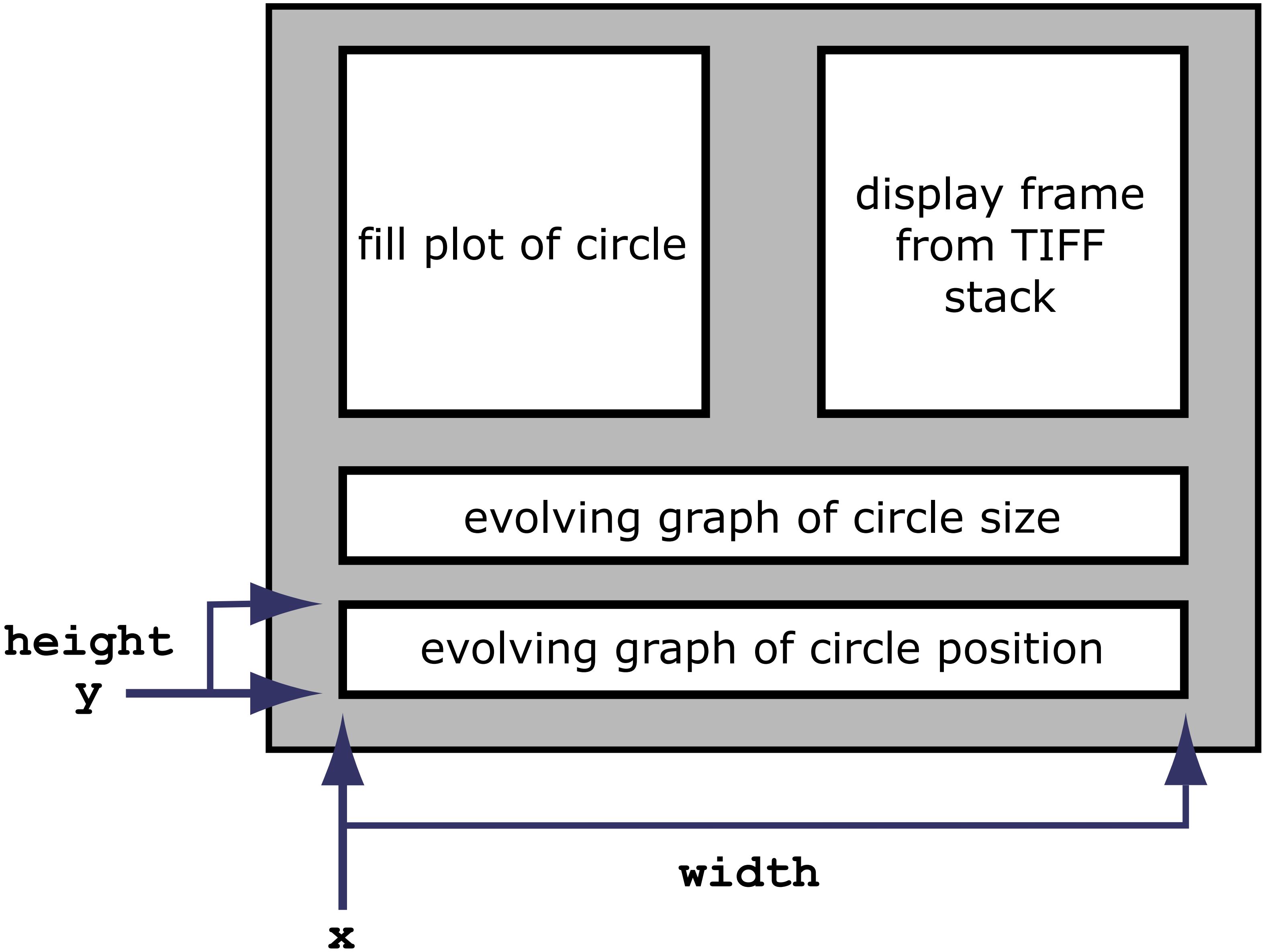
Planning and creating a multi-axes figure


fill plot of circle
display frame from TIFF stack
evolving graph of circle size
evolving graph of circle position
height
y
width
x

```
ax_pos = [x y width height];
ax_handle = axes;
set(ax_handle, 'Units', 'pixels', 'Position', ax_pos);
```

or relative sizing: `set(ax_handle, 'Units', 'normalized', 'Position', ax_pos);`

Planning and creating a multi-axes figure: collect positions in matrices

I like to set up position variables before entering the loop.

```
fig_pos = [100 10 1024 768]; % position and size of the figure window

fillplot_ax_pos = [80 320 400 400];         % position and size of fill plot
image_ax_pos = [580 320 400 400];           % image plot
sizedata_ax_pos = [50 170 1024-60 70];      % circle size graph
posdata_ax_pos = [50 50 1024-60 100];       % circle position graph
```

Axes in the loop will use these variables to position themselves on the figure

It's also useful to declare often-used colors at the onset

```
fig_col = [1 1 1];  % figure background color
text_col = [0 0 0]; % text color
light_grey = [.4 .4 .4];
dark_grey = [.2 .2 .2];
nice_blue = [51/255 51/255 102/255];
light_red = [.6 .4 .4];
```

All this makes it easier to change the appearance of various elements

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Set up the FOR loop: my recipe

Before the loop:

Set up figure window, use ‘Position’ property to set size

Declare where all the elements (axes) should be

flag that decides whether movie object is created

set to zero when setting up the layout etc.

if set to one: avifile function sets up movie object.

```
movieflag = 1;
moviefilename = 'tutorialmovie.avi';

% only if our flag is set to 1, will we open up a movie object:
if movieflag == 1
    aviobj = avifile(moviefilename, 'fps', 30, 'compression', 'none');
end

startframe = 1; endframe = 100;

fh= figure('color', fig_col, 'name', 'Tutorial animation movie', ...
    'Position', fig_pos);

for k = startframe:endframe

    % MAKE THE FIGURE
    %
    %

    if movieflag == 1
        frame = getframe(gcf);           % capture current figure
        aviobj = addframe(aviobj,frame); % append frame
    end
    if k < endframe
        clf; % clear figure except for very last frame
    end
end

if movieflag == 1
    aviobj = close(aviobj);
end
```

Set up the FOR loop: my recipe

In the loop:

Draw your axes in the figure window with data from time step k

if movieflag equals one, capture the current figure with `getframe()`

use `addframe()` to append frame to the movie object

clear the figure with `clf` if you're not at the last frame (seems to make stuff faster)

```
movieflag = 1;
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for k = startframe:endframe

    % MAKE THE FIGURE
    %
    %

    if movieflag == 1
        frame = getframe(gcf);             % capture current figure
        aviobj = addframe(aviobj,frame); % append frame
    end
    if k < endframe
        clf; % clear figure except for very last frame
    end
end

if movieflag == 1
    aviobj = close(aviobj);
end
```

Set up the FOR loop: my recipe

Out of the loop:

Close the movie object with `close()`, if the flag was set

```
moviefflag = 1;
```

```
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% only if our flag is set to 1, will we open up a movie object:
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    aviobj = avifile(moviefilename, 'fps', 30, 'compression', 'none');
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startframe = 1; endframe = 100;

fh= figure('color', fig_col, 'name', 'Tutorial animation movie', ...
    'Position', fig_pos);

for k = startframe:endframe

    % MAKE THE FIGURE
    %
    %

    if movieflag == 1
        frame = getframe(gcf);           % capture current figure
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Set up axes for images and data graphs

As mentioned, I like to set up position and color variable at the onset

`axes()` command uses position information to place axes accordingly

```
handle_ax = axes;
    set(handle_ax, 'Units', 'pixels', 'Position', handle_ax_pos);
```

```
p1h(1)=plot(xpos,ypos, '-.');
set(p1h(1), 'Color', light_grey, 'LineWidth', 2);
hold on;
p1h(2) = plot(.....
set(p1h(2), 'Color', light_red, 'LineWidth', 1);
hold off;
```

graphics handles allow fine-grained control over each element

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Load sequential images from image file (TIFF stack example)

imread(ind) loads images from a file. Certain files (GIF, TIFF) can contain multiple images in a stack. The ind tells the function which image it should pull from the stack.

```
image_ax = axes;
set(image_ax, 'Units', 'pixels', 'Position', image_ax_pos);
try
    img = imread('tiffstack.tiff', k); % load image of current index
catch ME1
    % Get last segment of the error message identifier.
    idSegLast = regexp(ME1.identifier, '(?<=:)\w+$', 'match');
    disp(idSegLast);
    error('Failed loading tiff image');
end
img = xor(1,img); % invert image to make it more exciting... XOR rules!
imagesc(img);  colormap gray;    axis off; axis image;

th=title('Inverted image from TIFF stack');
set(th, 'FontSize', 14);
```

imagesc(img) displays the image. colormap tells it what the numbers contained in the img array “mean”.

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set up the `FOR` loop

set up axes for images and data graphs

load sequential images from TIFF stack

● update information for each frame

save figure content into AVI movie file

`long and tedious code, see code listing`

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Save figure content into AVI movie file

`f = getframe(gcf)` captures the current figure window in variable `f`
`addframe(aviobj,f)` adds frame `f` to the open movie object (aviobj)

```
.
.
.
if movieflag == 1
        frame = getframe(gcf);           % capture current figure
        aviobj = addframe(aviobj,frame); % use addframe to append frame
    end
    if k < endframe
        clf; % clear figure except for very last frame
    end

end % of the big loop
fprintf('\nDone looping...\n');

if movieflag == 1
    fprintf('Saving movie...\n\n');
    aviobj = close(aviobj);
end
```

end of the
big movie loop

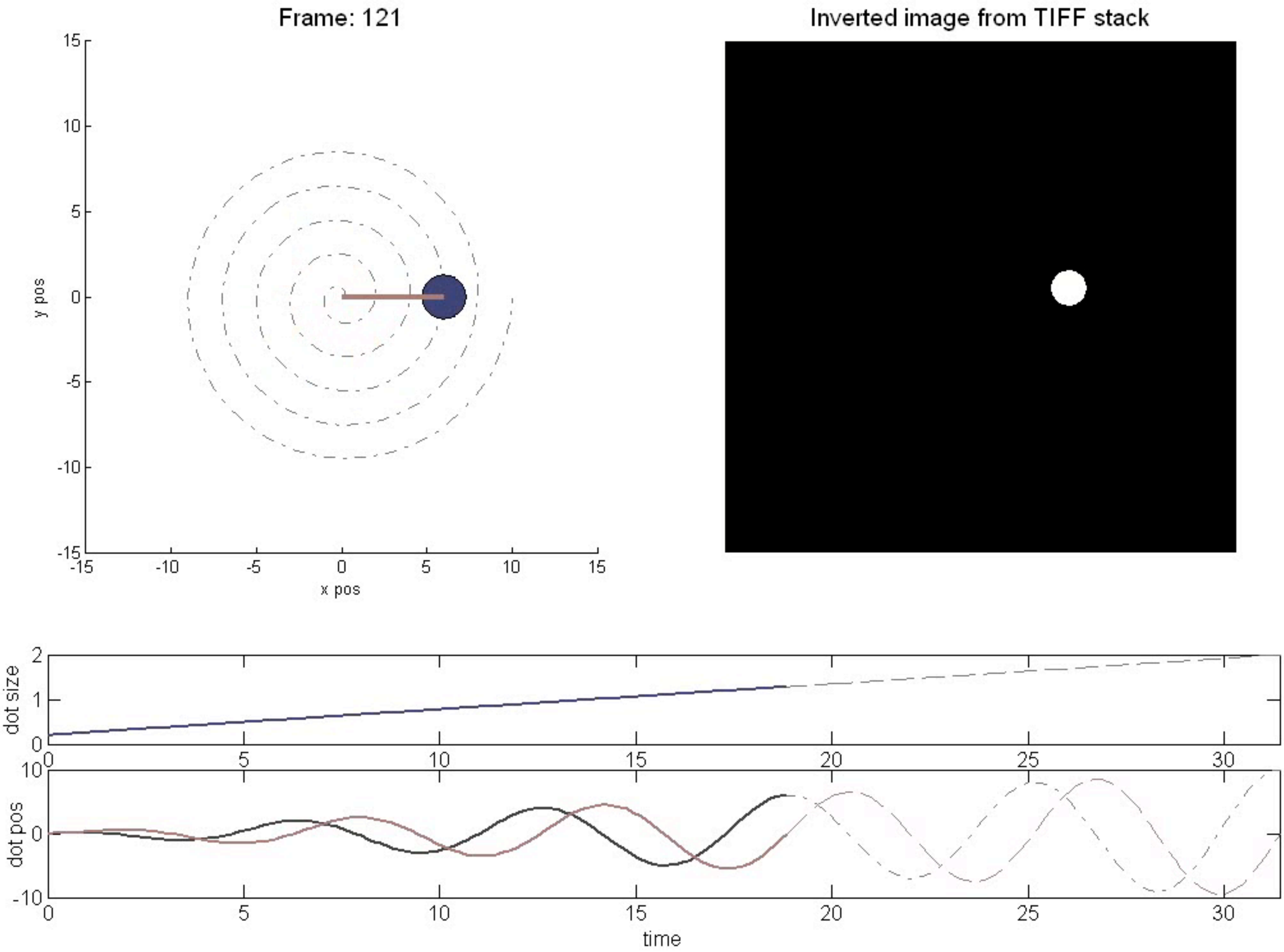
call `close(aviobj)` to close the movie object once we are done with the big loop

Compress movie with VirtualDub, Quicktime, or other movie editing software

Matlab can save already compressed files, but it seems faster and easier to just save uncompressed videos, and do the compression elsewhere

Compression rates are usually huge. E.g. for the tutorial video:

Uncompressed:	ca. 474 MB
XViD compressed:	ca. 492 KB


Frame: 121
y pos
x pos
15
10
5
0
-5
-10
-15
-15
-10
-5
0
5
10
15
Inverted image from TIFF stack
dot size
2
1
0
0
5
10
15
20
25
30
dot pos
10
0
-10
0
5
10
15
20
25
30
time