Introduction to Matlab

Problem 1)

Code File: **p3.m**

```
% Parse the data
[x, fs] = audio2bin('music.mp3');
sound(x, fs);

% Read formatted data
[x, fs] = bin2audio('music.bin');
sound(x, fs);

% Time range of interest
time = (0:(length(x) - 1)) / fs;
t1 = 1;
t2 = 1.01;

% Plot the time domain
subplot(2, 2, 1);
plot(time, x);
xlabel('time [seconds]', 'FontSize', 18);
ylabel('amplitude', 'FontSize', 18);
set(gca, 'FontSize', 16);
grid on;
xlim([t1 t2]);

% Plot the FFT
i1 = round(t1 * fs);
i2 = round(t2 * fs);
nfft = 2^12; % FFT size
freq = (((0:(nfft-1)) / nfft) - 0.5) * fs; % frequency [Hz]
X = fft(x(i1:i2,:), nfft); % Discrete Fourier Transform

subplot(2, 2, 2);
plot(freq, 20*log10(abs(fftshift(X)))); % use log axis
xlabel('frequency [Hz]', 'FontSize', 18);
ylabel('magnitude [dB]', 'FontSize', 18);
set(gca, 'FontSize', 16);
grid on;

% Plot the spectrograms
nfft = 2^8;
overlap = round(0.8*nfft);
window = hamming(nfft);

subplot(2, 2, 3);
spectrogram(x(:,1), window, overlap, nfft, fs);
set(gca, 'FontSize', 16);
grid on;

subplot(2, 2, 4);
spectrogram(x(:,2), window, overlap, nfft, fs);
set(gca, 'FontSize', 16);
grid on;
```

```
% View on oscilloscope
win_sec = 0.05;                 % window length [seconds]
win_sam = round(win_sec*fs);    % window length [samples]
step_sec = 0.001;               % step length [seconds]
step_sam = round(step_sec*fs);  % step length [samples]

figure;
han = plot(time(1:win_sam), x(1:win_sam));
drawnow;
ylim(0.1*[-1, 1]);
for i = win_sam:step_sam:length(x)
    ind = ((i - win_sam + 1):i);
    set(han, 'XData', time(ind), 'YData', x(ind));
    xlim(time(ind([1, end])));
    drawnow;
    pause(0.05);
end
```

Code File: **audio2bin.m**

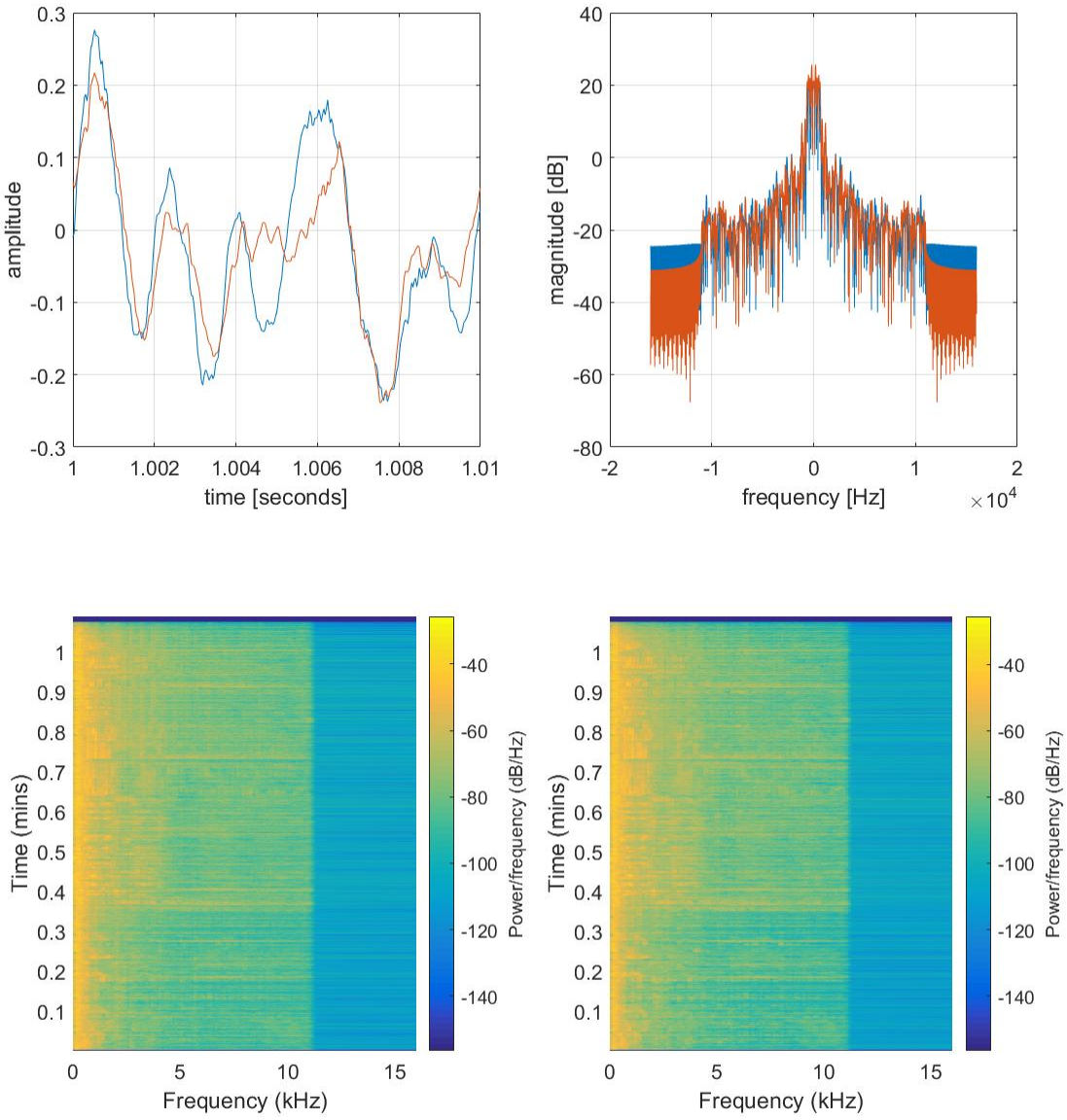
```
function [x, Fs] = audio2bin(fin, fout)
    % Construct output file name from input
    if (nargin < 2)
        fout = [fin(1:max(strfind(fin, '.'))), 'bin'];
    end

    % Path correction
    fin = [pwd,'\','Resources\',fin];
    fout = [pwd,'\','Output\',fout];
    fprintf('Input file = %s\n', fin);
    fprintf('Output file = %s\n', fout);

    % Read the audio file
    [x, Fs] = audioread(fin);
    fid = fopen(fout, 'wb');

    % Determine data dimensions
    channels = size(x, 2); % columns in x (size of second dimension)
    samples = size(x, 1); % rows in x

    % Write the header
    % ndim = 1 (audio)
    % nchan = channels
    % dim0 = samples
    % dim1 = Fs (for audio files)
    % dim2 = 0 (not used for audio)
    fwrite(fid, [1, channels, samples, Fs, 0], 'int');

    % Arrange channels by row so the (:) will coalesce correctly
    %transpose = x.';

    % Output the data
    %fwrite(fid, transpose(:), 'float');

    % Alternatively, use a simple for loop (so what, it's not efficient?)
    for i = 1:samples
        for j = 1:channels
            fwrite(fid, x(i, j), 'float');
        end
    end
    % Release the file handler
```

```
    fclose(fid);
end
```

Code File: **bin2audio.m**

```
function [x, Fs] = bin2audio(fin, fout)
    % Construct output file name from input
    if (nargin < 2)
        fout = [fin(1:max(strfind(fin, '.'))), 'wav'];
    end

    % Path correction
    fin = [pwd,'\','Output\',fin];
    fout = [pwd,'\','Output\',fout];
    fprintf('Input file = %s\n', fin);
    fprintf('Output file = %s\n', fout);

    % Read the header
    % ndim = 1 (audio)
    % nchan = channels
    % dim0 = samples
    % dim1 = Fs (for audio files)
    % dim2 = 0 (not used for audio)
    fid = fopen(fin, 'rb');
    ndim = fread(fid, 1, 'int');
    channels = fread(fid, 1, 'int');
    samples = fread(fid, 1, 'int');
    Fs = fread(fid, 1, 'int');
    dim2 = fread(fid, 1, 'int');

    % Read the data
    [a, ~] = fread(fid, inf, 'float');

    % Release the file handler
    fclose(fid);
    % Just use nested loops this time
    x = zeros(samples, channels);
    for i = 1:samples
        for j = 1:channels
            % i-1 because matlab is stupid with 1-based indexing
            x(i, j) = a((i - 1)*channels + j);
        end
    end

    % Write out the data
    audiowrite(fout, x, Fs);
end
```

In hindsight, I probably could have just done: `x(i, j) = fread(fid, 1, 'float');`
oh well….



Basically, Matlab was able to parse an audio file into a series of sampled values that I can later perform computation on in C.

Problem 2)

Code File: **p2.m**

```
% Parse the data
[x1] = image2bin('liftingbody.png');
[x2] = image2bin('coloredchips.png');

% Read formatted data
[x1] = bin2image('liftingbody.bin');
[x2] = bin2image('coloredchips.bin');

figure;

% Show gray-scale
subplot(1,2,1);
imagesc(x1, [100, 200]);
axis image;
colormap(gray);
colorbar;

% Show color
subplot(1,2,2);
image(x2);
axis image;
```

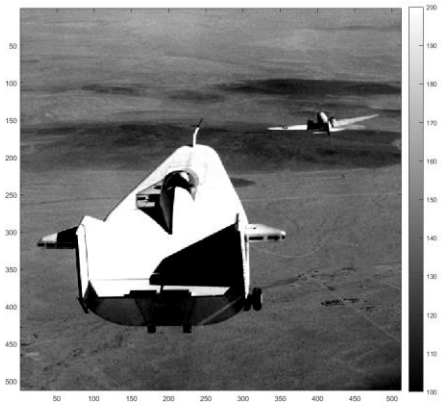
Code File: **image2bin.m**

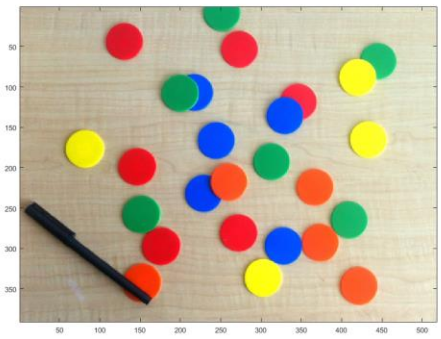
```
function [x] = image2bin(fin, fout)
    % Construct output file name from input
    if (nargin < 2)
        fout = [fin(1:max(strfind(fin, '.'))), 'bin'];
    end

    % Path correction
    fin = [pwd,'\','Resources\',fin];
    fout = [pwd,'\','Output\',fout];
    fprintf('Input file = %s\n', fin);
    fprintf('Output file = %s\n', fout);

    % read the image file
    x = imread(fin);

    % determine data dimensions
    [M, N, colors] = size(x); % rows, cols, 3 for color, 1 for grayscale

    % Write the header
    % ndim = 2 (image)
    % nchan = colors (RGB = 3, gray-scale = 1)
    % dim0 = M
    % dim1 = N
    % dim2 = 0 (not used for images)
    fid = fopen(fout, 'wb');
    fwrite(fid, [2, colors, M, N, 0], 'int');

    % Loop over pixel(i = row, j = col) -> R, G, B
    for i = 1:M
        for j = 1:N
            for k = 1:colors
                fwrite(fid, x(i, j, k), 'float');
```

```
            end
        end
    end

    % Release the file handler
    fclose(fid);
end
```

Code File: **bin2image.m**

```
function [x] = bin2image(fin, fout)
    % Construct output file name from input
    if (nargin < 2)
        fout = [fin(1:max(strfind(fin, '.'))), 'png'];
    end

    % Path correction
    fin = [pwd,'\','Output\',fin];
    fout = [pwd,'\','Output\',fout];
    fprintf('Input file = %s\n', fin);
    fprintf('Output file = %s\n', fout);

    % Read the header
    % ndim = 2 (image)
    % nchan = colors (RGB = 3, gray-scale = 1)
    % dim0 = M
    % dim1 = N
    % dim2 = 0 (not used for images)
    fid = fopen(fin, 'rb');
    ndim = fread(fid, 1, 'int');
    colors = fread(fid, 1, 'int');
    M = fread(fid, 1, 'int');
    N = fread(fid, 1, 'int');
    dim2 = fread(fid, 1, 'int');

    % Read the data
    [a, ~] = fread(fid, inf, 'float');

    % Release the file handler
    fclose(fid);

    % Just use nested loops this time
    x = zeros(M, N, colors);
    for i = 1:M
        for j = 1:N
            for k = 1:colors
                % 3 dimensional array access with 1-based indexing
                x(i, j, k) = a((i - 1)*N*colors + (j - 1)*colors + k);
            end
        end
    end

    % Because imwrite is stupid, and requires type uint8
    x = uint8(x);

    % Write out the data
    imwrite(x, fout, 'png');
end
```





In this case we were to parse images. The data processing is the same procedure as for audio processing, but the dimensions of the data we work with are different. Additionally, gray-scale uses one byte per pixel where standard color uses three.

Problem 3)

Code File: **p3.m**

```
% Parse the data
[vid] = video2bin('xylophone.mp4');

% Read formatted data
[file] = bin2video('xylophone.bin');
implay(file)
```

Code File: **video2bin.m**

```
function [vid] = video2bin(fin, fout)
    % Construct output file name from input
    if (nargin < 2)
        fout = [fin(1:max(strfind(fin, '.'))), 'bin'];
    end

    % Path correction
    fin = [pwd,'\','Resources\',fin];
    fout = [pwd,'\','Output\',fout];
    fprintf('Input file = %s\n', fin);
    fprintf('Output file = %s\n', fout);

    % read the video file
    vid = VideoReader(fin);
    frames = vid.NumberOfFrames; % apparently this is deprecated too?! >:|
    M = vid.Height;
    N = vid.Width;
    Fs = vid.FrameRate;
    %colors = vid.BitsPerPixel / 8;
    colors = 3; % we can't store it so we can't support differences here
    %x = read(vid); % read all frames - who cares that this is deprecated
    %[M, N, colors, frames] = size(x);

    % Write the header
    % ndim = 3 (video)
    % nchan = Fs
    % dim0 = M
    % dim1 = N
    % dim2 = frames
    fid = fopen(fout, 'wb');
    fwrite(fid, [3, Fs, M, N, frames], 'int');

    % Loop over pixel(i = row, j = col) -> R, G, B
    for f = 1:frames
        x = read(vid, f); % Don't care that this is deprecated, matlab sucks
        for i = 1:M
            for j = 1:N
                for k = 1:colors
                    fwrite(fid, x(i, j, k), 'float');
                end
            end
        end
    end

    % Release the file handler
    fclose(fid);
end
```

Code File: **bin2video.m**

```
function [fout] = bin2video(fin, fout)
    % Construct output file name from input
    if (nargin < 2)
        fout = [fin(1:max(strfind(fin, '.'))), 'mp4'];
    end

    % Path correction
    fin = [pwd,'\','Output\',fin];
    fout = [pwd,'\','Output\',fout];
    fprintf('Input file = %s\n', fin);
    fprintf('Output file = %s\n', fout);

    % Read the header
    % ndim = 3 (video)
    % nchan = Fs
    % dim0 = M
    % dim1 = N
    % dim2 = frames
    fid = fopen(fin, 'rb');
    ndim = fread(fid, 1, 'int');
    Fs = fread(fid, 1, 'int');
    M = fread(fid, 1, 'int');
    N = fread(fid, 1, 'int');
    frames = fread(fid, 1, 'int');
    colors = 3; % We can't support gray-scale videos

    %Write the data
    size_frame = M * N * colors;
    vid = VideoWriter(fout, 'MPEG-4');
    vid.FrameRate = Fs;
    open(vid);

    % Just use nested loops this time
    for f = 1:frames
        % Read frame by frame
        [a, ~] = fread(fid, size_frame, 'float');
        x = zeros(M, N, colors);

        for i = 1:M
            for j = 1:N
                for k = 1:colors
                    % 3 dimensional array access with 1-based indexing
                    x(i, j, k) = a(...
                        (i - 1) * N * colors + ...
                        (j - 1) * colors + ...
                        k);
                end
            end
        end

        % Convert to uint8 just like images
        x = uint8(x);
        writeVideo(vid, x);
    end

    % Release the file handlers
    fclose(fid);
    close(vid);
end
```

This is where I really had grief with Matlab. The VideoWriter object has deprecated NumberOfFrames, which we really need to do this efficiently. Additionally, being able to set the n^{th} frame of a video is deprecated and must be done sequentially. I can see this being a nuisance for some forms of data processing. Good thing we'll do that in C (I hope).