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% **Mobile Digital Camera Simulation**

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% Code developed in 2016/17 by Ed Fry for a PhD from University of

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% 1. **General User instructions**

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% Open AAA.MAIN\_CODE.m file – this is the main code file, used to call all % functions, and specify simulation parameters.

%

% Make sure in\_path and out\_path in % AAA.MAIN\_CODE.m refer to real

% folders. in\_path should contain the images to be processed. They should

% be ordered alpha-numerically, and be of the specified file type

% (currently .png files)

%

% Select desired settings in User Settings Dashboard (refer to Glossary of

% these settings if necessary) - ensure each string entered is identical to

% one of the options listed above each parameter. Refer to glossary of user % settings below if you are unsure of what they do.

%

% Settings you may wish to change may be:

% **Save\_Data** (to avoid saving cell all arrays during code development),

% **ApplyPreProc** (to toggle pre-processing on/off, as discussed during the

% meeting).

% **SNR\_names\_Cell** (to change the SNR settings of the simulation – don’t

% forget you will need to retune ALL of the following: Dark\_Noise\_Mean,

% Dark\_Noise\_SD, Expo\_adj, Blk\_lvl\_adj, and Wht\_lvl\_adj, if you change

% this. Talk to me if you need to do so – retuning can be complicated.

%

% Execute AAA.MAIN\_CODE.m to generate the images. Output images are saved

% in cell arrays in the out\_path folder at present.

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% 2. **Glossary of User Settings**

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%

% Linear\_Input – Toggling to ‘Yes’ disables the linearization process prior % to deonising. Only toggle to yes, if you have linearized all input images % (i.e. accounting for capture system gamma function).

%

% Linarise\_Output – Toggling to ‘Yes’ linearises all output images. Only

% toggle to yes if you require linear input images for later denoising,

% and/or sharpening algorithms (most require non-linearised images, so this % is unlikely).

%

% Save\_Data – Toggling to ‘Yes’ saves all output images in cell arrays in

% the folder specified by the out\_path string.

%

% Num\_Reps – Specifies the number of repeated captures of each input image. % Leave this as ‘1’ unless repeated processing of each image is needed.

%

% Cam\_Type – Specifies which camera’s F-number, pixel and sensor dimensions

% to use. You can either setup your own in the system\_spec.m function, or

% use the default (iPhone 6). This information is used in lens blur

% modelling.

%

% Blur\_Type – Specifies the type of lens blur modelling to use. Default is % a diffraction limited lens airy disc model, which is most appropriate.

%

% Bayer\_Type – Specifies the type of Bayer pattern to demosaic from. The

% ImgProc\_Demosaic.m file automatically sets up the demosaicing method

% specified, per the Bayer\_Type and Demosaic\_Type parameters. You can

% specify a new mosaic array type in ImgProc\_RGB2Bayer.m, but make sure it % is supported by the demosaicing algorithm you want to use first.

%

% SNR\_names\_Cell – Specifies numerically the SNRs for which noise is to be % modelled. Make sure SNR\_names\_II has identical values to SNR\_names\_Cell.

%

% PV\_for\_SNR – Specifies the pixel value for which the SNR should be

% calculated for. A normalised pixel value of 1 was previously used, to

% calculate the SNR for a saturated pixel, rather than its mean value, or a

% mid-grey value.

%

% Gamma – Specifies the gamma value to be used to describe the tone

% reproduction of the system.

%

% CCM\_R\_Gain and CCM\_B\_Gain – Specify the gain values applied to R and G

% channel pixels, since the quantum efficiency of these pixels is lower

% than the G channel. This scales up the noise in these channels during the % noise modelling process. Leave as default.

%

% Dark\_Noise\_Mean and Dark\_Noise\_SD – Specify the mean and standard

% deviation of a Gaussian approximation for sensor dark noise at each SNR; % this increases at lower SNRs.

%

% ApplyPreProc – Specifies whether you wish for pre-processing adjustments % to be applied. Note these were tuned to optimise visual image quality

% prior to denoising and/or sharpening. It is not known whether these

% adjustments are appropriate when output images are for a CNN, hence why

% it can be toggled on/off as an option.

%

% Expo\_adj – Specifies the level of gain (exposure adjustment) to be

% applied by image pre-processing. This is higher at lower SNRs.

%

% Blk\_lvl\_adj – Specifies the level of black level adjustment to be applied % at each SNR, which is applied with greater intensity at lower SNRs. This % removes the noise floor in the image, and keeps the contrast natural.

%

% Wht\_lvl\_adj – Specifies the level of white level adjustment to be applied % at each SNR, which is greater in intensity at lower SNRs. This performs

% highlight recovery, ensuring that valuable information is not clipped or % lost in later image processing.

%

% Demosaic\_Type – Specifies which demosaicing algorithm to use when running % the ImgProc\_Demosaic.m function. Uses Malvar by default (which is linear, % non-adaptive, fast and very high quality).

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% 3. **Simulation Workflow**

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% AAA\_MAIN\_CODE.m performs simulations in the following stages:

%

% STAGE 1. User Settings Dashboard:

% User specifies simulation settings here

%

% STAGE 2. Preparatory Calculations:

% pre-allocates cell arrays per user settings in Stage 1.

%

% <=== LOOP ACROSS ALL INPUT IMAGES BEGINS HERE

%

% STAGE 3. Loading of Images:

% Loads image from in\_path folder, duplicates image into replicates.

%

% STAGE 4. Blur Modelling

% Blurs image replicates according to user specification, outputs

% blurred images as img.Blur.Gauss{replicate\_number} cell array.

%

% <=== LOOP ACROSS REPLICATES BEGINS HERE

%

% STAGE 5. Image: Noise modelling

% Adds noise to images according to specified SNRs, outputs noisy

% images to img.Poiss structure.

%

% STAGE 7. Conversion to Bayer Mosaic

% Converts RGB images to Bayer images, and outputs to img.Bayer

% structure as well as i dimension of Img\_Cell{rep, i}

%

% STAGE 8. Demosiaicing

% Performs demosaicing as specified by user in STAGE 1.

% Overwrites the the i dimension of Img\_Cell{rep, i}

% <=== LOOP ACROSS REPLICATES ENDS HERE

%

% STAGE 12. Assemble Output Cell Arrays

% Output cell arrays are formed from working cell arrays, including:

% All\_Imgs{p\_im, rep, i } from Img\_Cell{rep, i }

% All\_IDs{p\_im, rep, i } from ID\_Cell{rep, i }

% All\_Orig\_Imgs{p\_im} from img.Orig

%

% <=== LOOP ACROSS ALL INPUT IMAGES ENDS HERE

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% STAGE 14: Saving Output Cell Arrays

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%  **4. Accessing Images in Working Cell Arrays**

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% Working cell arrays (e.g. Img\_Cell) are used to process images during

% loops. At the end of the loop, the values are copied into the respective % output cell array (e.g. All\_Imgs).

% List of working cell arrays:

Img\_Cell{rep,i} - Contains processed images,

ID\_Cell{rep,i} - Contains image processing information,

Orig\_Img\_Cell{rep} – Contains unprocessed (original) images,

% For the Img\_Cell working cell array, the corresponding position in ID\_Cell array gives information regarding processing. The following dimensions exist:

% rep is a number describing which replicate is being processed.

% i is a number describing which signal to noise ratio is being used, % where SNR\_names\_II(i) gives the SNR value numerically.

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% 5. **Accessing Images in Output Cell Arrays**

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% Output cell arrays are filled after each image is processed. An additional dimension is included before all others, to specify which image has been processed.

% List of output cell arrays:

All\_Imgs{p\_im,rep,i } - Contains processed images, from Img\_Cell.

All\_IDs{p\_im,rep,i } - Contains image processing information, from ID\_Cell.

All\_Orig\_Imgs{p\_im, rep} – Contains unprocessed (original) images, from Orig\_Img\_Cell.