**Nel and JanenVanResnsberg Range Alignment Algorithm**

**Variables of interest**

* UnalignedMatrix (dimensions N x M): input unaligned range profiles
  + N – number of range bins
  + M – number of range profiles
  + So, each column is a range profile
* AlignedMatrix (dimensions N x M)
* Reference profile (dimension: N x 1)
* BinShifts\_NonInteger – non integer bin shifts to consider (dimensions: P x 1)

**Step 0: initialisation**

* AlignedMatrix = zeros(N,M)
* AlignedMatrix(:,1) = UnalignedMatrix(:,1) % first profile
* RefProfile = abs(UnalignedMatrix(:,1)); % first profile
* BinShifts\_NonInteger = -0.5:0.0025:0.5; % number of non-integer bin shifts to consider
* m = 2; % variable used to align the current profile of interest

**Step 1: shift mth unaligned profile by non-integer bin shifts given by ‘**BinShifts\_NonInteger’

* ProfileToAlign = UnalignedMatrix(:, m);
* Shift the mth unaligned profile by non-integer bin shifts specified by **‘**BinShifts\_NonInteger’
* The output here is a matrix called ‘ShiftedMthProfile’, where
  + The first column of ‘ShiftedMthProfile’ is the ProfileToAlign shifted by the value specified by the 1st element of **‘**BinShifts\_NonInteger’
  + The second column of ‘ShiftedMthProfile’ is the ProfileToAlign shifted by the value specified by the 2nd element of **‘**BinShifts\_NonInteger’
  + The third column of ‘ShiftedMthProfile’ is the ProfileToAlign shifted by the value specified by the 3rd element of **‘**BinShifts\_NonInteger’
  + ….
  + The last column of ‘ShiftedMthProfile’ is the ProfileToAlign shifted by the value specified by the last lement of **‘**BinShifts\_NonInteger’

**Step 2: Identify the non-integer bin shift that gives the highest correlation value**

* Perform the following operation to find the correlation values
  + RefProfileMatrix= repmat(RefProfile, P, 1);
  + CorrelationValuesMatrix = RefProfileMatrix .\* abs(ShiftedMthProfile);
  + CorrelationVector = sum(CorrelationValuesMatrix, 2); % sum in 1st dimension
* Write code to find the peak of CorrelationVector and store the non-integer bin shift in a vector ‘BinShiftFound’
  + [MaxVal MaxIdx] = max(CorrelationVector)
  + BinShiftFound(m) = BinShifts\_NonInteger(MaxIdx)
* Store aligned profile into a vector
  + AlignedProfile = ShiftedMthProfile(:,MaxIdx);

**Step 3: Save aligned profile found in step 2 into ‘**AlignedMatrix’

* AlignedMatrix(: , m) = AlignedProfile;

**Step 4: Update the bin shift vector, so previously found ‘bin shift’ in step 2 is in the middle**

* BinShifts\_NonInteger = BinShifts\_NonInteger + BinShiftFound(m)

**Step 5: Compute new reference profile that is the mean of the previously mth aligned profile**

* Reference profile = abs(AlignedMatrix(: , 1: m) ); % only take the m profiles that have been aligned

**Step 6: increment m until all the profiles are aligned**

* Increment m: m = m + 1. Now go back to step 1
* Stop when m = M. This means that all the profiles have been aligned and the ‘BinShiftFound’ variable is fully populated
* Read further, because the algorithm is not yet complete.

When you have finished step 6, now you have the following vector

* BinShiftFound (dimensions: M x 1)

Fit a low order polynomial to ‘BinShiftFound’ to get ‘BinShiftFoundSmooth’. Look at using the functions polyval() and polyfit() to aid with this task. Lastly, perform the non-integer bin shifts of the UnalignedMatrix using the ‘BinShiftFoundSmooth’ vector. Perform this in the frequency domain, since the bin shifts are non-integers.