```
%================================ flowme ================================
%
%  script flowme
%
%  This is a script stub that will execute the optical flow solver to be
%  written for this homework.  The script code will not work as is, and
%  must be adjusted.  The dynamic range of the images definitely needs to
%  be adjusted, as may the smoothness of the image data.
%
%
%  Variables in the script:
%    source         - which image sequence source to use.
%    di             - vector spacing for quiver.
%    scale                  - what scale to use for plotting vector field.
%    alphasqGD          - the value of alpha squared for optical flow.
%    iterGD                 - the number of iterations in the solver.
%    dt             - the gradient update step size.
%
%================================ flowme ================================

figure_count = 1;
%==(0) Setup variables and get images ready.
close all
load('optflowData.mat');
sources = {'box','bonanza','fish3','fish4'};
for i=1:length(sources)
  source = sources(i);
  source = source{1};
  switch source
   case 'box'
    I1 = imsmooth(box(:,:,1),0.5);
    I2 = imsmooth(box(:,:,3),0.5);
    scale = 2;
    alphasqGD = 0.017;
    iterGD = 6000;
    dt = 0.005;
    di = 1;
  case 'bonanza'
    I1 = imsmooth(bonanza(:,:,1),3);
    I2 = imsmooth(bonanza(:,:,4),3);
    scale = 10;
    alphasqGD = 0.02;
    iterGD = 4000;
    dt = 0.00002;
    di = 5;
  case 'fish3'
    I1 = imsmooth(fish03(:,:,1),3);
    I2 = imsmooth(fish03(:,:,20),3);
    scale = 2.0;
    alphasqGD = 0.007;
    iterGD = 1000;
    dt = 0.0002;
    di = 5;
  case 'fish4'
    I1 = imsmooth(fish04(:,:,1),3);
    I2 = imsmooth(fish04(:,:,12),3);
    scale = 2.0;
    alphasqGD = 1.2;
    iterGD = 11000;
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  dt = 0.00002;
  di = 5;
end

  %==(1) Actually compute the optical flow.
  [X.u, X.v] = optflowGD(I1, I2, alphasqGD, iterGD, dt);

  lenX = abs(X.u + i*X.v);
  disp(['The max length optical vector is: ' num2str(max(lenX(:)))]);

  %==(2) Display output of the optical flow.
  j = 8 * (i - 1);
  figure(j + 1);
    imagesc(I1);
    colormap('gray');
    axis image;
    title(strcat(source,' I1'));
  figure(j + 2);
    imagesc(I2);
    colormap('gray');
    axis image;
    title(strcat(source, ' I2'));
  figure(j + 3);
    imagesc(I2-I1);
    colormap('gray');
    colorbar;
    axis image;
    title(strcat(source,' I2 - I1'));
  figure(j + 4);
    imagesc(X.u);
    colorbar;
    axis image;
    title(strcat(source,' u'));
  figure(j + 5);
    imagesc(X.v);
    colorbar;
    axis image;
    title(strcat(source, ' v'));
  figure(j + 6);
    imagesc(I1);
    colormap('gray');
    axis image;
    [M, N] = size(I1);
    subx = [1:di:N];
    suby = [1:di:M];
    [gridx, gridy] = meshgrid(subx, suby);
    hold on;
    quiver(gridx, gridy, X.u(suby,subx),X.v(suby, subx),scale,'Color','r');
    hold off;
    title(strcat(source,' I1 + Vector Field'));

  intI = optflow_check(I1, I2, X);

  figure(j + 7);
    imagesc(intI);
    colormap('gray');
    axis image;
    title(strcat(source, ' Warped I1'));

  figure(j + 8);
    imagesc(I2 - intI);
```
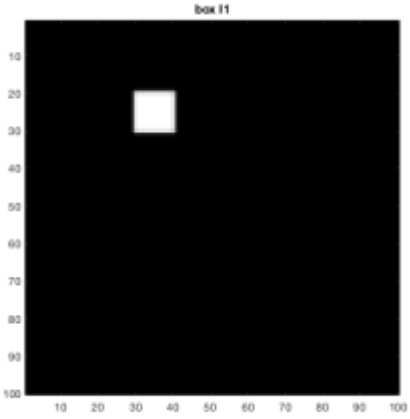
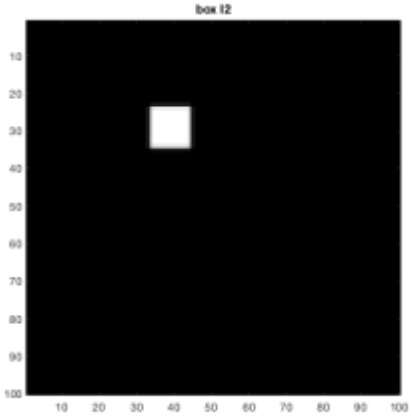
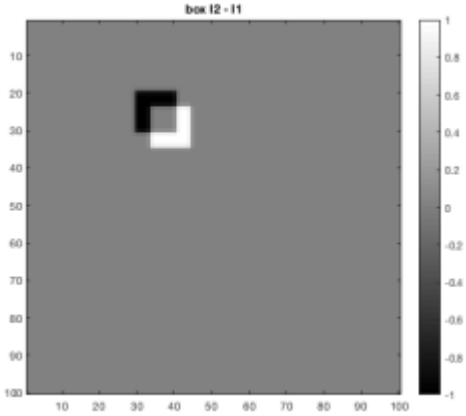

```
      colorbar;
      title(strcat(source,' Error Between I1 + Velocity and I2'));

end

%============================== optflowGD ================================
%
%  [Xu, Xv] = optflowGD(I1, I2, alphasq, iter, dt)
%
%
%  Implements the gradient descent optical flow algorithm based upon
%  the energy functional of Horn and Schunck.  Computes the optical flow
%  between two images.
%
%  Inputs:
%    I1         -the first image in time.
%    I2         -the second image in time.
%    alphasq    -the parameter alpha^2.
%    iter       -number of gradient descent iterations.
%    dt         -the timestep to use in gradient descent.
%
%============================== optflowGD ================================
function [Xu, Xv] = optflowGD(I1, I2, alphasq, iter, dt)

Xu = zeros(size(I1));                   % This is our initial guess.
Xv = zeros(size(I2));

[Ix, Iy, It] = differentialsGD(I1, I2);

for i=1:iter
  lapXu = laplacian(Xu);
  lapXv = laplacian(Xv);

  grad = Ix .* Xu + Iy .* Xv + It;

  Xu = Xu - dt*(grad .* Ix - alphasq * lapXu);
  Xv = Xv - dt*(grad .* Iy - alphasq * lapXv);
end


end
%-------------------------- differentialsGD --------------------------
%
% [Ix, Iy, It] = differentialsGD
%
%-------------------------- differentialsGD --------------------------
function [Ix, Iy, It] = differentialsGD(I1, I2)

Kt = (1.0/4.0)*[1,1;1,1];
Kx = (1.0/4.0)*[-1,1;-1,1];
Ky = (1.0/4.0)*[-1,-1;1,1];

It = imfilter(I2, Kt) - imfilter(I1, Kt);
Ix = imfilter(I1, Kx) + imfilter(I2, Kx);
Iy = imfilter(I1, Ky) + imfilter(I2, Ky);

end

%---------------------------- laplacian -----------------------------
%
% [ubar] = laplacian(u)
```

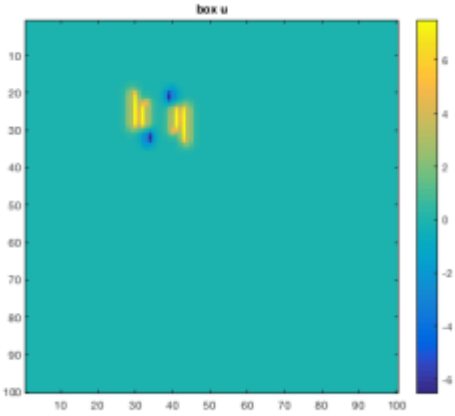
```
%
%------------------------------ laplacian ------------------------------
function [lapu] = laplacian(u)
k = 3;
A = (1/12.0)*[1,2,1;2,0,2;1,2,1];
lapu = k * u + imfilter(u, k * A);
end
```

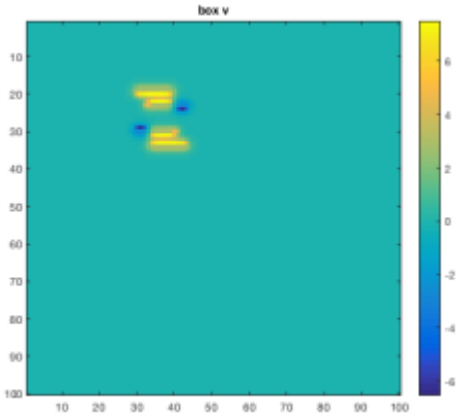
```
The max length optical vector is: 10.9237
The max length optical vector is: 22.7509
The max length optical vector is: 44.9485
The max length optical vector is: 102.8549
```

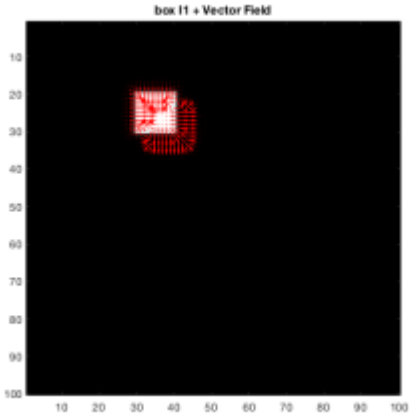

box I1

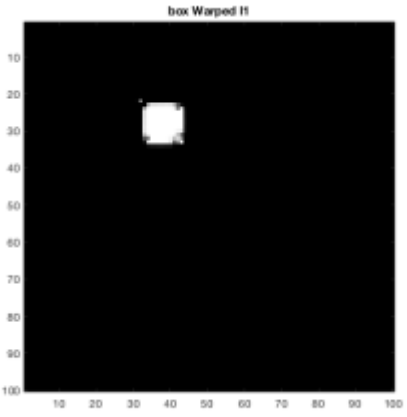

box I2

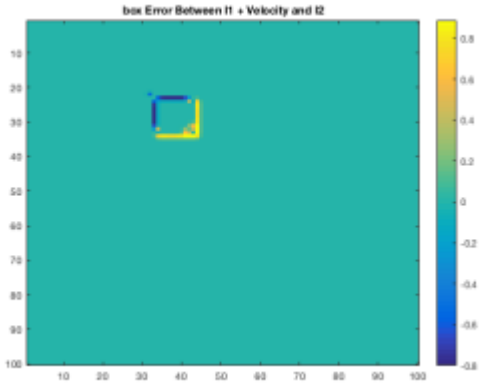

box I2 - I1

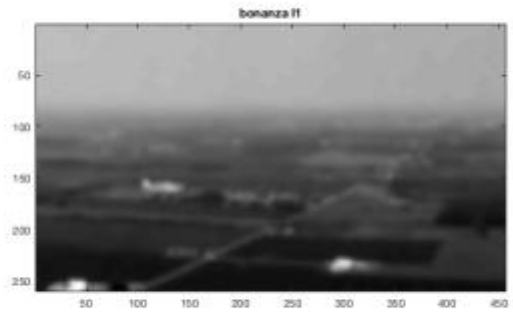

box u

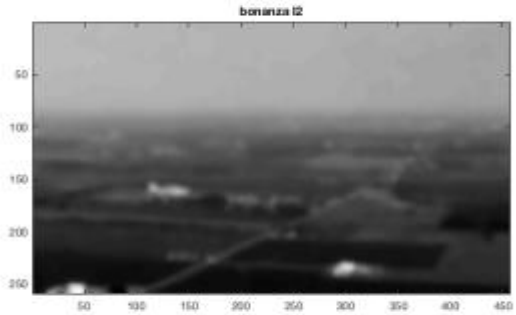

box v

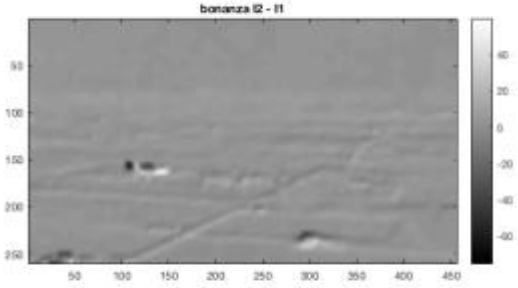

box I1 + Vector Field

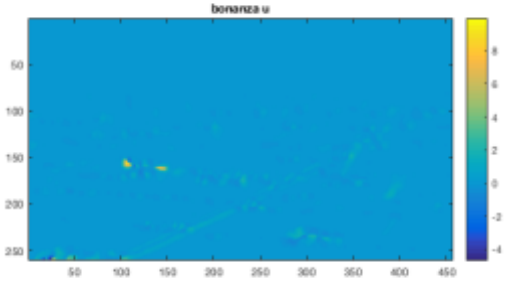

box Warped I1

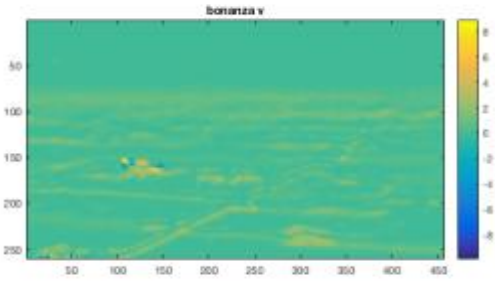

box Error Between I1 + Velocity and I2

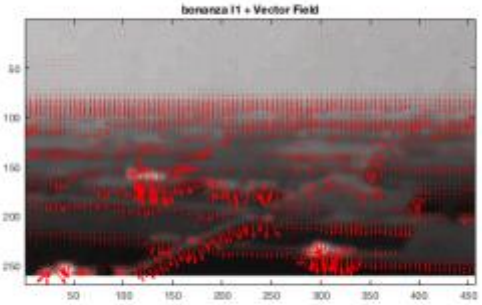

bonanza I1

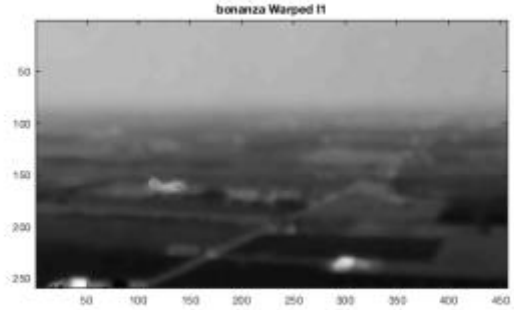

bonanza I2

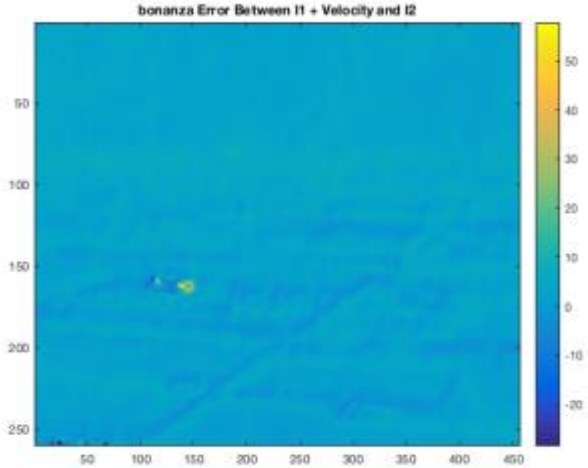

bonanza I2 - I1

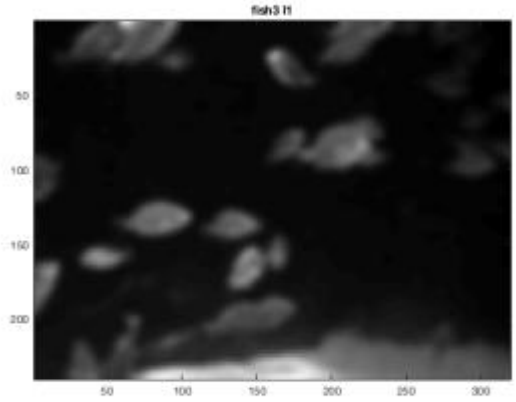

bonanza u

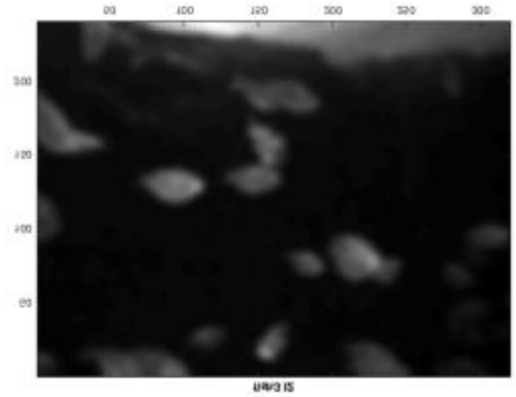

bonanza v

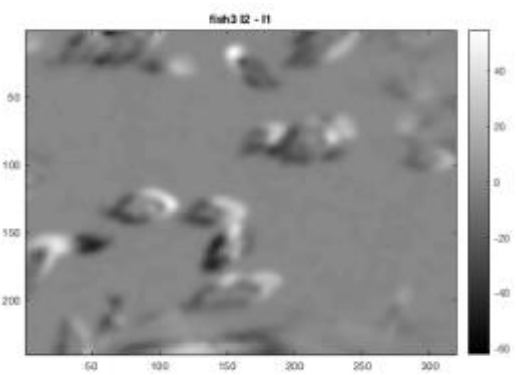

bonanza I1 + Vector Field

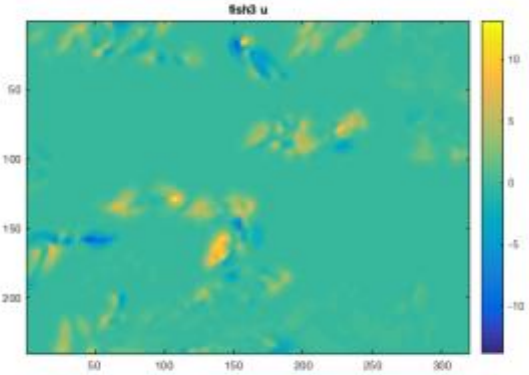

bonanza Warped I1

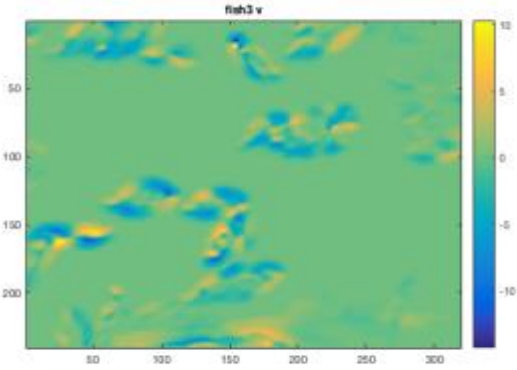

bonanza Error Between I1 + Velocity and I2

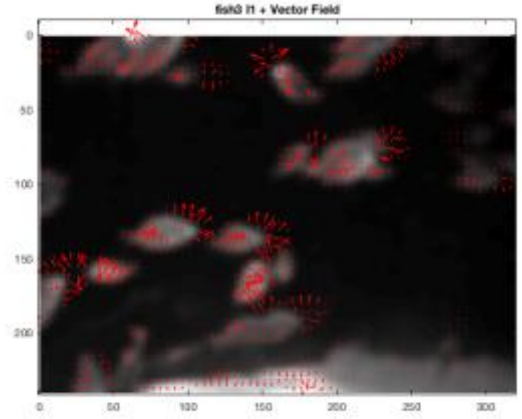

fish3 I1

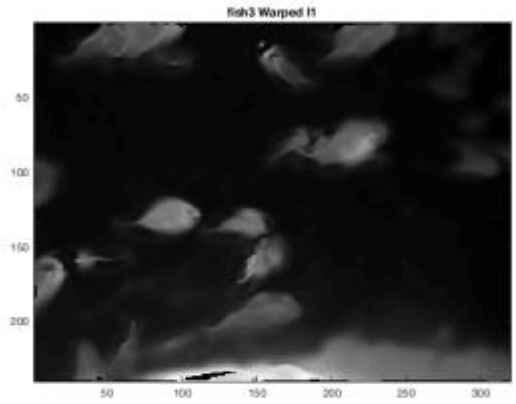


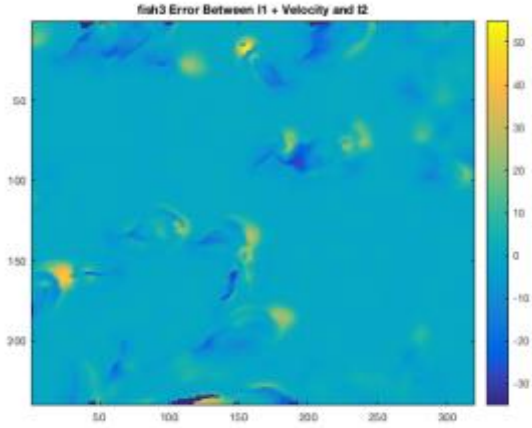

fish3 I2 - I1

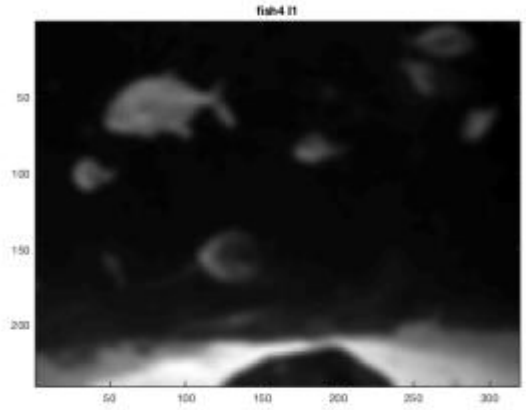

fish3 u

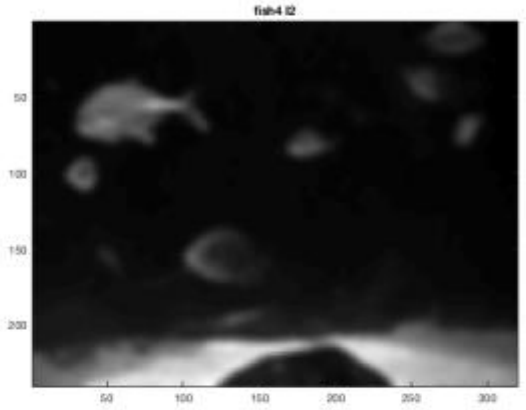

fish3 v

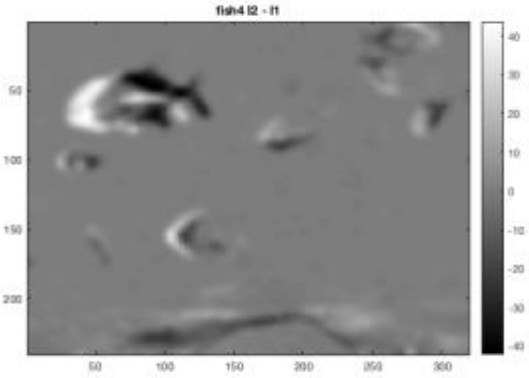

fish3 I1 + Vector Field

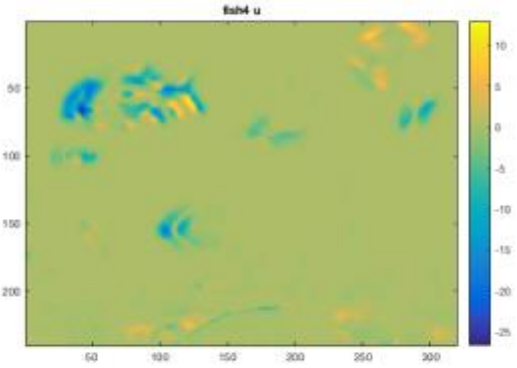

fish3 Warped I1

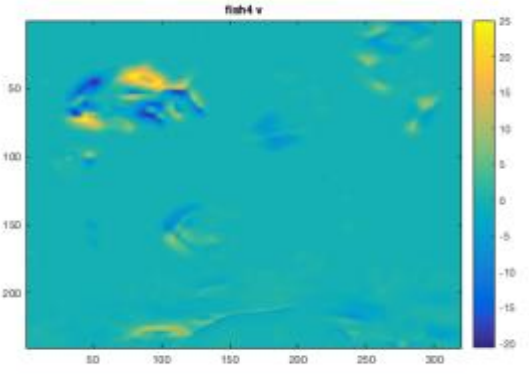

fish3 Error Between I1 + Velocity and I2

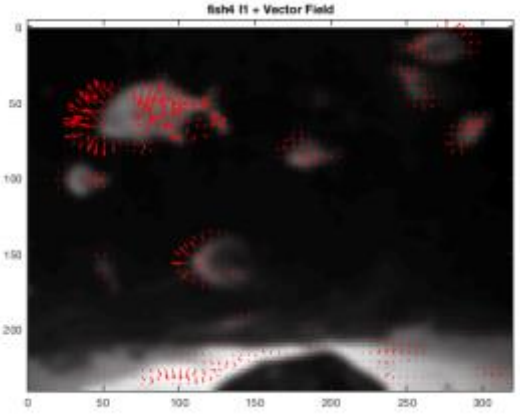

fish4 I1

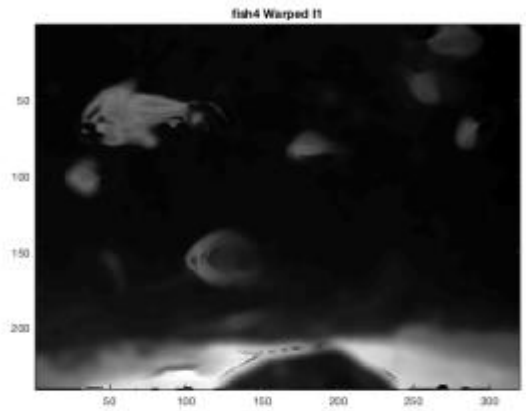

fish4 I2

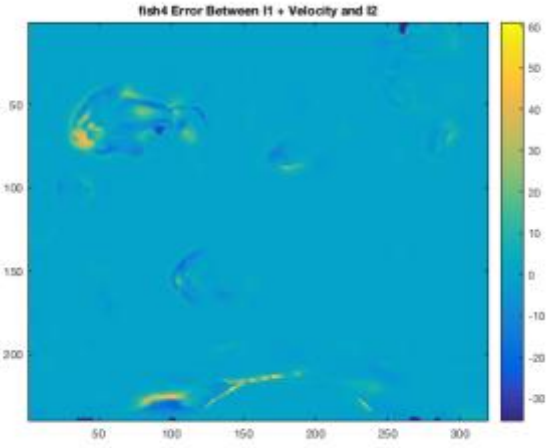

fish4 I2 - I1


fish4 u


fish4 v


fish4 I1 + Vector Field


fish4 Warped I1


fish4 Error Between I1 + Velocity and I2