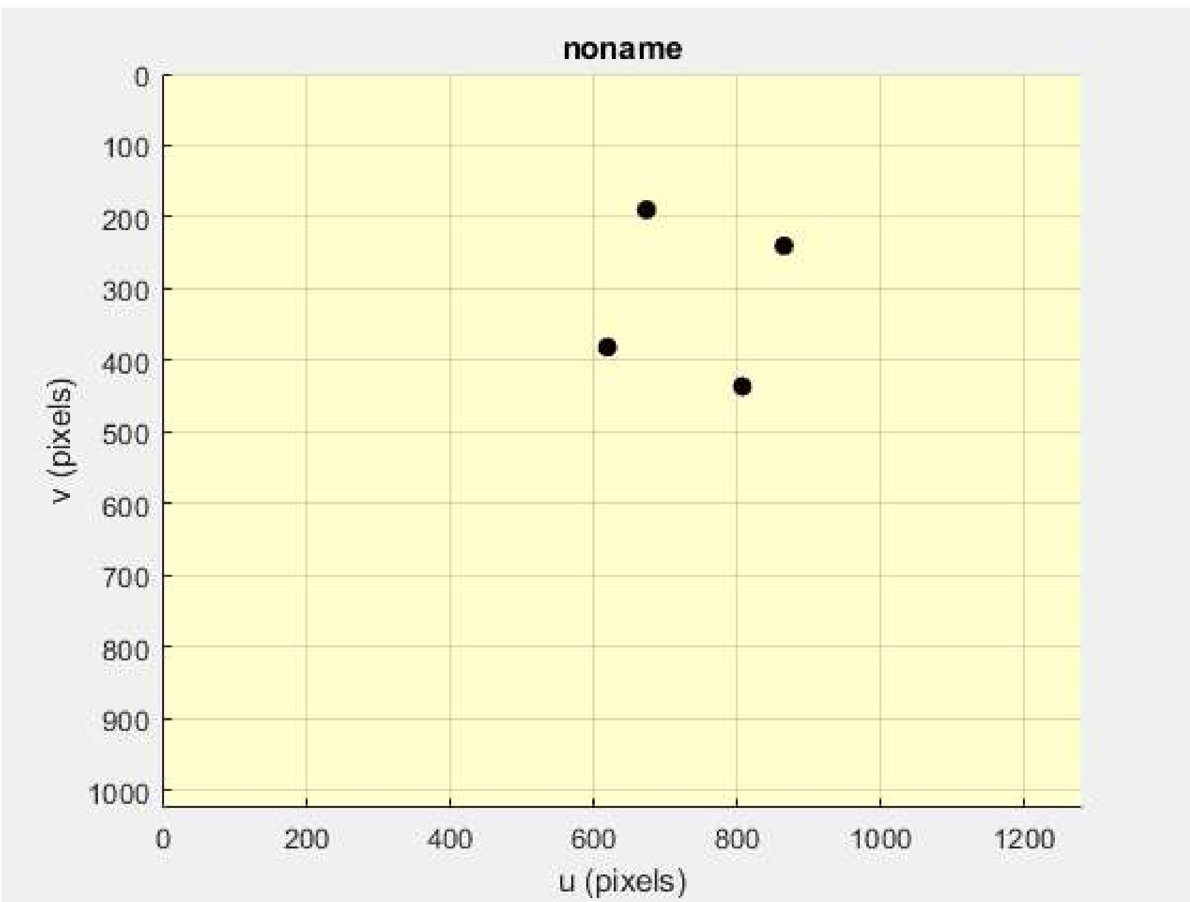
Iterative Closest Point Algorithm

```
startup_rvc;
```

```
Robotics, Vision & Control: (c) Peter Corke 1992-2011 http://www.petercorke.com
- Robotics Toolbox for MATLAB (release 10.2)
Warning: "C:\Users\Andy\Documents\MATLAB\Add-Ons\Toolboxes\Robotics Toolbox for MATLAB\code\ro
 - ARTE contributed code: 3D models for robot manipulators (C:\Users\Andy\Documents\MATLAB\Add
 - pHRIWARE (release 1.1): pHRIWARE is Copyrighted by Bryan Moutrie (2013-2018) (c)
Run rtbdemo to explore the toolbox
principal point not specified, setting it to centre of image plane
creating new figure for camera
h = 
  Axes (noname) with properties:

             XLim: [0 1280]
             YLim: [0 1024]
           XScale: 'linear'
           YScale: 'linear'
    GridLineStyle: '-'
         Position: [0.1300 0.1100 0.7750 0.8150]
            Units: 'normalized'

  Show all properties
make axes
```



```
maximum residual 2.344e-13


cTt =
    0.9363   -0.2751    0.2184       0.1
    0.2896    0.9564   -0.0370      -0.2
   -0.1987    0.0978    0.9752       1.5
         0         0         0         1
cTt_estimate =
    0.9363   -0.2751    0.2184    0.1000
    0.2896    0.9564   -0.0370   -0.2000
   -0.1987    0.0978    0.9752    1.5000
         0         0         0    1.0000
```

- using peter corkes library for SE3 conversions

Setup two point clouds, P and Q, separated by a transformation matrix `qTp`.

```
qTp = SE3(0.1, -0.2, 1.5) * SE3.rpy(0.1, 0.2, 0.3);
N = 20;
P = randn(3, N);
Qh = qTp.T*e2h(P);
Q = h2e(Qh);
```

Part a: Create `pq2tr` function, run it on the two point clouds and compare result ot `qTp`.

```
T = pq2tr(P, Q)
```

```
T =
    0.9363   -0.2751    0.2184    0.1000
    0.2896    0.9564   -0.0370   -0.2000
   -0.1987    0.0978    0.9752    1.5000
         0         0         0    1.0000
```

```
qTp
```

```
qTp =
    0.9363   -0.2751    0.2184       0.1
    0.2896    0.9564   -0.0370      -0.2
   -0.1987    0.0978    0.9752       1.5
         0         0         0         1
```

Match Confirmed.

Part b: Relax our assumption that we know the correspondances for each pair of points between the two clouds.

```
Pr = P(:, randperm(N));
Qr = Q(:, randperm(N));
```

Use the `closest` algorithm to determine the closest points between the two data sets.

```
corresp = closest(Pr, Qr);
[Pr_closest,Qr_closest] = unique_pairs(Pr, Qr, corresp);
```

Run `pq2tr` again on this permutation of the point clouds.

```
Tb = pq2tr(Pr_closest, Qr_closest)
```

```
Tb =

    0.9928    0.0210   -0.1181    0.0506
   -0.0105    0.9960    0.0890    0.0329
    0.1195   -0.0871    0.9890    0.4056
         0         0         0    1.0000
```

Here we see that Tb is different than the actual transformation matrix because the structural information that relates points from one cloud to the next is lost. Instead of using this exact correspondance, we are instead just estimating a transition matrix to move the cloud in a manner that reduces the distance between the closest point pairs. This is an insufficient method to finding the exact transformation between the two point clouds, and will require an iterative process that uses this estimate to move the point cloud `Pr` to this new position where the process can then be repeated and hopefully are larger subset of the point pairs can be deemed 'closest' to each other and therefore give a better representation of the true point correspondance based on the structure of the cloud.

Part c: corresp = closest(Pr, Qr); Implement `icp_simple` that runs `pq2tr` multiple times to give a better estimate of the transition matrix.

```
Tc = icp_simple(Pr, Qr, 10)
```

```
Iteration: 1
    Current mean distance:  0.92331
Iteration: 2
    Current mean distance:  0.86497
Iteration: 3
    Current mean distance:  0.79068
Iteration: 4
    Current mean distance:  0.54581
Iteration: 5
    Current mean distance:  0.067627
Iteration: 6
    Current mean distance:  1.2202e-15
Iteration: 7
    Current mean distance:  1.3411e-15
Iteration: 8
    Current mean distance:  1.3761e-15
Iteration: 9
    Current mean distance:  1.3751e-15
Iteration: 10
    Current mean distance:  1.5403e-15
```

```
Tc =

    0.9363   -0.2751    0.2184    0.1000
    0.2896    0.9564   -0.0370   -0.2000
   -0.1987    0.0978    0.9752    1.5000
         0         0         0    1.0000
```

Here we have seen that the mean distance between the point clouds had rapidly decreased even within 10 iterations of the ICP algorithm. Additionally, the `Tc` variable representing the true estimate of the transition matrix matches `qTp`.