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A: Covariance Matrix

```
X = [7 4 3
    4 1 8
    6 3 5
    8 6 1
    8 5 7
    7 2 9
    5 3 3
    9 5 8
    7 4 5
    8 2 2];

S = covarianceMat(X)
```

```
S =

    2.3222    1.6111   -0.4333
    1.6111    2.5000   -1.2778
   -0.4333   -1.2778    7.8778
```

B: Covariance matrix Eigen values and vectors

```
[eigVect, eigVals] = eig(S)
```

```
eigVect =

    0.7017    0.6990   -0.1376
   -0.7075    0.6609   -0.2505
   -0.0842    0.2731    0.9583


eigVals =

    0.7499         0         0
         0    3.6761         0
         0         0    8.2739
```

C: Sorting Eigen Vectors by Eigen Values descending

```
eigVectOrg = eigVect;
d = diag(eigVals);
[~, ind] = sort(d, 'descend');
eigVect = eigVect(:,ind)
```

```
eigVect =

   -0.1376    0.6990    0.7017
   -0.2505    0.6609   -0.7075
    0.9583    0.2731   -0.0842
```

D: Mapped Data using Covariance Eigen vectors

```
mappedX = (X * eigVectOrg)

fprintf("\t\ta * eig1 + b * eig2 + c * eig3 = (mappedX1 mappedX2
 mappedX3)\n")
n = size(X,1);
for i=1:n
    fprintf("%g * (%4.2f %4.2f %4.2f) + %g * (%4.2f %4.2f %4.2f) + %g
 * (%4.2f %4.2f %4.2f) = (%4.1f %4.1f %4.1f)\n", ...
        X(i,1), eigVectOrg(:,1),X(i,2), eigVectOrg(:,2), X(i,3),
 eigVectOrg(:,3), mappedX(i,:));
end
```

```
mappedX =

    1.8298    8.3561    0.9101
    1.4262    5.6417    6.8657
    1.6672    7.5423    3.2147
    1.2849    9.8307   -1.6450
    1.4874   10.8083    4.3553
    2.7397    8.6728    7.1608
    1.1338    6.2971    1.4357
    2.1050   11.7804    5.1760
    1.6615    8.9022    2.8267
    4.0306    7.4602    0.3151

  a * eig1 + b * eig2 + c * eig3 = (mappedX1 mappedX2 mappedX3)
7 * (0.70 -0.71 -0.08) + 4 * (0.70 0.66 0.27) + 3 * (-0.14 -0.25 0.96)
 = ( 1.8  8.4  0.9)
4 * (0.70 -0.71 -0.08) + 1 * (0.70 0.66 0.27) + 8 * (-0.14 -0.25 0.96)
 = ( 1.4  5.6  6.9)
```

```
6 * (0.70 -0.71 -0.08) + 3 * (0.70 0.66 0.27) + 5 * (-0.14 -0.25 0.96)
 = ( 1.7  7.5  3.2)
8 * (0.70 -0.71 -0.08) + 6 * (0.70 0.66 0.27) + 1 * (-0.14 -0.25 0.96)
 = ( 1.3  9.8 -1.6)
8 * (0.70 -0.71 -0.08) + 5 * (0.70 0.66 0.27) + 7 * (-0.14 -0.25 0.96)
 = ( 1.5 10.8  4.4)
7 * (0.70 -0.71 -0.08) + 2 * (0.70 0.66 0.27) + 9 * (-0.14 -0.25 0.96)
 = ( 2.7  8.7  7.2)
5 * (0.70 -0.71 -0.08) + 3 * (0.70 0.66 0.27) + 3 * (-0.14 -0.25 0.96)
 = ( 1.1  6.3  1.4)
9 * (0.70 -0.71 -0.08) + 5 * (0.70 0.66 0.27) + 8 * (-0.14 -0.25 0.96)
 = ( 2.1 11.8  5.2)
7 * (0.70 -0.71 -0.08) + 4 * (0.70 0.66 0.27) + 5 * (-0.14 -0.25 0.96)
 = ( 1.7  8.9  2.8)
8 * (0.70 -0.71 -0.08) + 2 * (0.70 0.66 0.27) + 2 * (-0.14 -0.25 0.96)
 = ( 4.0  7.5  0.3)
```

E: Show the new Data is linear independent

The covariance matrix is diagonal

```
mappedS = covarianceMat(mappedX)
```

```
mappedS =

    0.7499   -0.0000    0.0000
   -0.0000    3.6761   -0.0000
    0.0000   -0.0000    8.2739
```

F: Show original Data as linear combination of new Data and Eigen Vectors

```
fprintf("\t\ta * eig1 + b * eig2 + c * eig3 = (X1 X2 X3)\n")
n = size(X,1);
for i=1:n
    fprintf("%g * (%4.2f %4.2f %4.2f) + %g * (%4.2f %4.2f %4.2f) + %g
 * (%4.2f %4.2f %4.2f) = (%4.1f %4.1f %4.1f)\n", ...
        X(i,1), eigVectOrg(:,1),X(i,2), eigVectOrg(:,2), X(i,3),
 eigVectOrg(:,3), mappedX(i,:));
end
```

```
  a * eig1 + b * eig2 + c * eig3 = (X1 X2 X3)
7 * (0.70 -0.71 -0.08) + 4 * (0.70 0.66 0.27) + 3 * (-0.14 -0.25 0.96)
 = ( 1.8  8.4  0.9)
4 * (0.70 -0.71 -0.08) + 1 * (0.70 0.66 0.27) + 8 * (-0.14 -0.25 0.96)
 = ( 1.4  5.6  6.9)
6 * (0.70 -0.71 -0.08) + 3 * (0.70 0.66 0.27) + 5 * (-0.14 -0.25 0.96)
 = ( 1.7  7.5  3.2)
8 * (0.70 -0.71 -0.08) + 6 * (0.70 0.66 0.27) + 1 * (-0.14 -0.25 0.96)
 = ( 1.3  9.8 -1.6)
```

```
8 * (0.70 -0.71 -0.08) + 5 * (0.70 0.66 0.27) + 7 * (-0.14 -0.25 0.96)
 = ( 1.5 10.8  4.4)
7 * (0.70 -0.71 -0.08) + 2 * (0.70 0.66 0.27) + 9 * (-0.14 -0.25 0.96)
 = ( 2.7  8.7  7.2)
5 * (0.70 -0.71 -0.08) + 3 * (0.70 0.66 0.27) + 3 * (-0.14 -0.25 0.96)
 = ( 1.1  6.3  1.4)
9 * (0.70 -0.71 -0.08) + 5 * (0.70 0.66 0.27) + 8 * (-0.14 -0.25 0.96)
 = ( 2.1 11.8  5.2)
7 * (0.70 -0.71 -0.08) + 4 * (0.70 0.66 0.27) + 5 * (-0.14 -0.25 0.96)
 = ( 1.7  8.9  2.8)
8 * (0.70 -0.71 -0.08) + 2 * (0.70 0.66 0.27) + 2 * (-0.14 -0.25 0.96)
 = ( 4.0  7.5  0.3)
```

G: Map data to one feature data.

```
reductionMappedX = X * eigVect(:,1:2)
```

```
reductionMappedX =

    0.9101    8.3561
    6.8657    5.6417
    3.2147    7.5423
   -1.6450    9.8307
    4.3553   10.8083
    7.1608    8.6728
    1.4357    6.2971
    5.1760   11.7804
    2.8267    8.9022
    0.3151    7.4602
```

The Feature Reduction Error is:

```
err = min(diag(eigVals))
```

```
err =

    0.7499
```

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