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Math 220 Linear Algebra

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Computer Project Report

1. Matlab code:

   A = [0 0.125 0.26; 0.33 0 0; 0 0.85 0.85]

   lambda = eig(A)

   Outout:

```
A =
                0    0.1250    0.2600
         0.3300          0         0
                0    0.8500    0.8500
lambda =
         -0.0436 + 0.1962i
         -0.0436 - 0.1962i
         0.9371
```

   Analysis:

   Since λ3, the largest eigenvalue of vector A, is 0.9371, which is less than 1, the population of spotted owls is becoming extinct. In the previous example provided, the largest eigenvalue λ1 was 1.01, which is larger than the current λ3 of 0.9371. The population of owls in this case is worse off than in the example since this population is decreasing while the population in the example is increasing.

2. Matlab code:

   A = [0 0 0.19 0.44 0.50 0.50 0.45;

   0.77 0 0 0 0 0 0;

   0 0.77 0 0 0 0 0;

   0 0 0.77 0 0 0 0;

   0 0 0 0.77 0 0 0;

   0 0 0 0 0.77 0 0;

   0 0 0 0 0 0.77 0.78;]

   [V, lambda] = eig(A)

   multiplier = [0; 0; 0; 0; 0; 1; 0;]

   V6= V*multiplier

   V6_percentages = V6/(sum(V6)

Output:

```
A =
         0         0    0.1900    0.4400    0.5000    0.5000    0.4500
    0.7700         0         0         0         0         0         0
         0    0.7700         0         0         0         0         0
         0         0    0.7700         0         0         0         0
         0         0         0    0.7700         0         0         0
         0         0         0         0    0.7700         0         0
         0         0         0         0         0    0.7700    0.7800
V =
  Columns 1 through 4
   0.0587             0.0104 + 0.0363i   0.0104 - 0.0363i  -0.1569 - 0.0329i
  -0.0967             0.0447 - 0.0511i   0.0447 + 0.0511i  -0.0948 + 0.1823i
   0.1594            -0.1210 - 0.0179i  -0.1210 + 0.0179i   0.1923 + 0.1800i
  -0.2628             0.0910 + 0.2006i   0.0910 - 0.2006i   0.2885 - 0.1752i
   0.4333             0.2149 - 0.3335i   0.2149 + 0.3335i  -0.1166 - 0.4166i
  -0.7144            -0.7145            -0.7145            -0.5544
   0.4411             0.4829 + 0.1715i   0.4829 - 0.1715i   0.3681 + 0.3446i
  Columns 5 through 7
  -0.1569 + 0.0329i   0.5685            -0.0130
  -0.0948 - 0.1823i   0.4346            -0.0263
   0.1923 - 0.1800i   0.3323            -0.0534
   0.2885 + 0.1752i   0.2540            -0.1084
  -0.1166 + 0.4166i   0.1942            -0.2200
  -0.5544             0.1485            -0.4466
   0.3681 - 0.3446i   0.5031             0.8583
lambda =
  Columns 1 through 4
  -0.4670                  0                  0                  0
         0            -0.2316 + 0.3594i        0                  0
         0                  0            -0.2316 - 0.3594i        0
         0                  0                  0            0.1619 + 0.5786i
         0                  0                  0                  0
         0                  0                  0                  0
         0                  0                  0                  0
  Columns 5 through 7
         0                  0                  0
         0                  0                  0
         0                  0                  0
         0                  0                  0
   0.1619 - 0.5786i         0                  0
         0             1.0072                  0
         0                  0             0.3793
multiplier =
     0
     0
     0
     0
     0
     1
     0
V6 =
    0.5685
    0.4346
    0.3323
    0.2540
```

```
    0.1942
    0.1485
    0.5031
V6_percentages =
    0.2335
    0.1785
    0.1364
    0.1043
    0.0797
    0.0610
    0.2066
```

Analysis:

Since λ6, the largest eigenvalue, is 1.0072, which is greater than 1, the blue whale population is increasing. That means the blue whale population is not becoming extinct. In the stable population eigenvector V6 contains the ratio of each class in relation to each other. By dividing V6 with the sum of its entries, we get the percentage of each class. In this case, whales under 2 years make up 23% of the population, whales 2 or 3 years make up 18% of the population, whales 4 or 5 years make up 14% of the population, whales 6 or 7 years make up 10% of the population, whales 8 or 9 years old make up 8% of the population, whales 10 to 11 years old make up 6% of the population, and whales 12 to 13 years old make up 21% of the population.

3. Matlab code:

```
A = [0.78 0.02 0.06 0.1 0.14;
0.12 0.76 0 0 0;
0 0.12 0.86 0 0;
0 0 0.14 0.58 0;
0 0 0 0.38 0.83;]
[V, lambda] = eig(A)
```

Outout:

```
A =
    0.7800    0.0200    0.0600    0.1000    0.1400
    0.1200    0.7600         0         0         0
         0    0.1200    0.8600         0         0
         0         0    0.1400    0.5800         0
         0         0         0    0.3800    0.8300
V =
  Columns 1 through 4
   0.3536 + 0.0897i   0.3536 - 0.0897i   0.6397             0.3246 - 0.3969i
  -0.2648 - 0.1299i  -0.2648 + 0.1299i   0.3797            -0.2218 - 0.3853i
   0.1198 + 0.0786i   0.1198 - 0.0786i   0.4461            -0.2395 + 0.2999i
   0.4284 - 0.0610i   0.4284 + 0.0610i   0.1634            -0.0325 + 0.2016i
  -0.7564            -0.7564             0.4700             0.5920
  Column 5
   0.3246 + 0.3969i
  -0.2218 + 0.3853i
  -0.2395 - 0.2999i
  -0.0325 - 0.2016i
   0.5920
lambda =
  Columns 1 through 4
   0.6148 + 0.0306i        0                  0                  0
        0             0.6148 - 0.0306i        0                  0
```

```
         0                   0              0.9621                   0
         0                   0                   0              0.8091 + 0.1294i
         0                   0                   0                   0
  Column 5
         0
         0
         0
         0
    0.8091 - 0.1294i
```

Analysis:

The largest eigenvalue, λ3, is 0.9621, which is less than 1, so the population of Alder is becoming extinct.

4. Matlab code:

```
A = [0.78 0.06 0.18 0.30 0.42;
0.12 0.76 0 0 0;
0 0.12 0.86 0 0;
0 0 0.14 0.58 0;
0 0 0 0.38 0.83;]
[V, lambda] = eig(A)
multiplier = [1; 0; 0; 0; 0;]
V1= V*multiplier
V1_percentages = V1/sum(V1)
h = (lambda(1,1)-1)/lambda(1,1)
```

Output:

```
A =
    0.7800    0.0600    0.1800    0.3000    0.4200
    0.1200    0.7600         0         0         0
         0    0.1200    0.8600         0         0
         0         0    0.1400    0.5800         0
         0         0         0    0.3800    0.8300
V =
  Columns 1 through 4
  -0.8350             0.6270             0.6270            -0.6968
  -0.3948            -0.3790 - 0.1551i  -0.3790 + 0.1551i  -0.1347 + 0.4647i
  -0.3080             0.1413 + 0.1053i   0.1413 - 0.1053i   0.3338 - 0.0069i
  -0.0994             0.2476 - 0.2489i   0.2476 + 0.2489i   0.1319 - 0.1002i
  -0.2055            -0.4669 + 0.2586i  -0.4669 - 0.2586i  -0.2647 - 0.2672i
  Column 5
  -0.6968
  -0.1347 - 0.4647i
   0.3338 + 0.0069i
   0.1319 + 0.1002i
  -0.2647 + 0.2672i
lambda =
  Columns 1 through 4
   1.0138                   0                   0                   0
         0             0.5900 + 0.0696i         0                   0
         0                   0             0.5900 - 0.0696i         0
         0                   0                   0              0.8081 + 0.1660i
```

```
         0                   0                   0                   0
  Column 5
         0
         0
         0
         0
   0.8081 - 0.1660i
multiplier =
     1
     0
     0
     0
     0
V1 =
   -0.8350
   -0.3948
   -0.3080
   -0.0994
   -0.2055
V1_percentages =
    0.4532
    0.2142
    0.1671
    0.0539
    0.1115
h =
    0.0136
```

Analysis:

The largest eigenvalue λ1 is 1.0138 is greater than 1, so the Alder population is not becoming extinct. The eigenvector V1 represents the ratio of classes in relation to each other. Alders with stems less than 0.1 cm are 45% of the population, alders with stems of 0.1-0.9 cm are 21% of the population, alders with stems of 1-1.9 cm are 17% of the population, alders with stems of 2-2.9 cm are 6% of the population, and alders with stems of 3-3.9 are 11% of the population. The percentage of alders that can be harvested while keeping the population constant, h, is 1.36%.

5. Matlab Code:

```
A = [0 0 0.19 0.44 0.50 0.50 0.45;
0.77 0 0 0 0 0 0;
0 0.77 0 0 0 0 0;
0 0 0.77 0 0 0 0;
0 0 0 0.77 0 0 0;
0 0 0 0 0.77 0 0;
0 0 0 0 0 0.77 0.78;]
[V, lambda] = eig(A)
h = (lambda(6,6)-1)/lambda(6,6)
```

Output:

```
A =
         0         0    0.1900    0.4400    0.5000    0.5000    0.4500
    0.7700         0         0         0         0         0         0
         0    0.7700         0         0         0         0         0
         0         0    0.7700         0         0         0         0
```

```
         0         0         0    0.7700         0         0         0
         0         0         0         0    0.7700         0         0
         0         0         0         0         0    0.7700    0.7800
V =
  Columns 1 through 4
   0.0587            0.0104 + 0.0363i   0.0104 - 0.0363i  -0.1569 - 0.0329i
  -0.0967            0.0447 - 0.0511i   0.0447 + 0.0511i  -0.0948 + 0.1823i
   0.1594           -0.1210 - 0.0179i  -0.1210 + 0.0179i   0.1923 + 0.1800i
  -0.2628            0.0910 + 0.2006i   0.0910 - 0.2006i   0.2885 - 0.1752i
   0.4333            0.2149 - 0.3335i   0.2149 + 0.3335i  -0.1166 - 0.4166i
  -0.7144           -0.7145            -0.7145            -0.5544
   0.4411            0.4829 + 0.1715i   0.4829 - 0.1715i   0.3681 + 0.3446i
  Columns 5 through 7
  -0.1569 + 0.0329i   0.5685           -0.0130
  -0.0948 - 0.1823i   0.4346           -0.0263
   0.1923 - 0.1800i   0.3323           -0.0534
   0.2885 + 0.1752i   0.2540           -0.1084
  -0.1166 + 0.4166i   0.1942           -0.2200
  -0.5544             0.1485           -0.4466
   0.3681 - 0.3446i   0.5031            0.8583
lambda =
  Columns 1 through 4
  -0.4670                  0                  0                  0
         0           -0.2316 + 0.3594i        0                  0
         0                  0           -0.2316 - 0.3594i        0
         0                  0                  0           0.1619 + 0.5786i
         0                  0                  0                  0
         0                  0                  0                  0
         0                  0                  0                  0
  Columns 5 through 7
         0                  0                  0
         0                  0                  0
         0                  0                  0
         0                  0                  0
   0.1619 - 0.5786i         0                  0
         0            1.0072                   0
         0                  0            0.3793
h =
    0.0072
```

Analysis:

The percentage of the whale population that can be harvested each year while keeping the population constant, h, is 0.72%.