HW 5

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In[54]:=
```
SetDirectory[NotebookDirectory[]];
file = Rest[Import["stormofswords.csv"]];
tribes = Import["tribes.csv"];
nodes = Flatten[tribes[[All, 1]]];
edges = #[[1]] ⟷ #[[2]] & /@ file [[All, {1, 2}]];
GWight = Graph[nodes, edges, EdgeWeight → file[[All, 3]]];
T = Graph[nodes, edges]
```

Out[60]=

PercolationCentrality is a graph centrality measure that quantifies the vulnerability of a network to targeted attacks . Specifically, it measures how much the removal of nodes from a graph affects the connectivity of the remaining nodes . The idea behind percolation centrality is to simulate the process of randomly removing nodes from a graph and measuring the size of the largest connected component in the remaining graph at each step . The nodes that, when removed, cause the largest drops in the size of the largest connected component are considered the most important nodes in terms of percolation centrality .

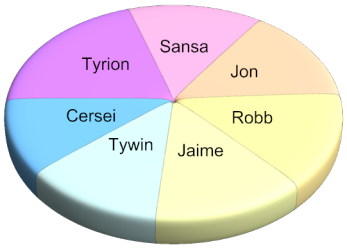
- Centrality measures for "Network of Thrones"

With weight

Degree centrality

In[63]:=
```
degreeCentralityW =
  Transpose[{Part[VertexList[GWight], Ordering[DegreeCentrality[GWight], 7, Greater]],
    Part[DegreeCentrality[GWight], Ordering[DegreeCentrality[GWight], 7, Greater]]}];
PieChart3D[degreeCentralityW[[All, 2]], ChartLabels → degreeCentralityW[[All, 1]],
 ChartStyle → "Pastel", PlotTheme → "Business", ImageSize → Medium]
```

Out[64]=

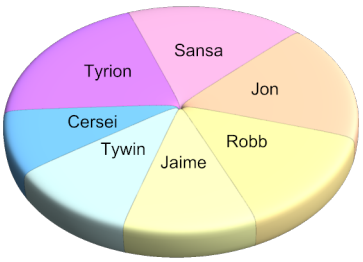


Betweenness Centrality

In[65]:=
```
betweennessCentralityW = Transpose[
   {Part[VertexList[GWight], Ordering[BetweennessCentrality[GWight], 7, Greater]],
    Part[BetweennessCentrality[GWight],
     Ordering[BetweennessCentrality[GWight], 7, Greater]]}];

PieChart3D[betweennessCentralityW[[All, 2]], ChartLabels → degreeCentralityW[[All, 1]],
 ChartStyle → "Pastel", PlotTheme → "Business", ImageSize → Medium]
```

Out[66]=

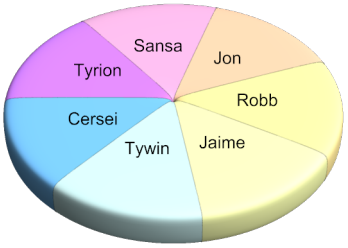


Closeness Centrality

In[67]:=
```
closenessCentralityW = Transpose[
    {Part[VertexList[GWight], Ordering[ClosenessCentrality[GWight], 7, Greater]],
     Part[ClosenessCentrality[GWight],
      Ordering[ClosenessCentrality[GWight], 7, Greater]]}];

PieChart3D[closenessCentralityW[[All, 2]], ChartLabels → degreeCentralityW[[All, 1]],
 ChartStyle → "Pastel", PlotTheme → "Business", ImageSize → Medium]
```

Out[68]=

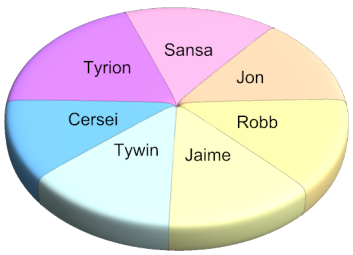


Page Rank Centrality

In[69]:=
```
pageCentralityW =
  Transpose[
   {Part[VertexList[GWight], Ordering[PageRankCentrality[GWight], 7, Greater]], Part[
     PageRankCentrality[GWight], Ordering[PageRankCentrality[GWight], 7, Greater]]}];

PieChart3D[pageCentralityW[[All, 2]], ChartLabels → degreeCentralityW[[All, 1]],
 ChartStyle → "Pastel", PlotTheme → "Business", ImageSize → Medium]
```

Out[70]=

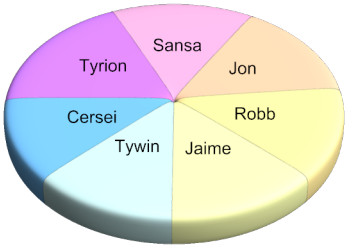


Eigen Vector Centrality

In[71]:=
```
eigenvectorCentralityW = Transpose[
    {Part[VertexList[GWight], Ordering[EigenvectorCentrality[GWight], 7, Greater]],
     Part[EigenvectorCentrality[GWight],
      Ordering[EigenvectorCentrality[GWight], 7, Greater]]}];

PieChart3D[eigenvectorCentralityW[[All, 2]], ChartLabels → degreeCentralityW[[All, 1]],
 ChartStyle → "Pastel", PlotTheme → "Business", ImageSize → Medium]
```

Out[72]=



Without weight

- We calculated Centrality for a graph without weights, for each vertex

In[200]:=
```
(*Compute degree centrality*)
degreeCentrality = VertexDegree[T] / (VertexCount[T] - 1);
(*Compute betweenness centrality*)
betweennessCentrality = BetweennessCentrality[T];
(*Compute eigenvector centrality*)
eigenvectorCentrality = EigenvectorCentrality[T];
(*Compute closeness centrality*)
closenessCentrality = ClosenessCentrality[T];
(*Compute Page Rank centrality*)
pagerankCentrality = PageRankCentrality[T];
```

In[205]:=
```
(*Print the results*)
Print["Degree centrality: ", degreeCentrality];
Print["================================================================="];
Print["Betweenness centrality: ", betweennessCentrality];
Print["================================================================="];
Print["Closeness centrality: ", closenessCentrality];
Print["================================================================="];
Print["Eigenvector centrality: ", eigenvectorCentrality];
Print["================================================================="];
Print["page Rank centrality: ", pagerankCentrality];
Print["================================================================="];
```

Degree centrality:

$$\left\{\frac{1}{106}, \frac{5}{106}, \frac{2}{53}, \frac{3}{106}, \frac{1}{106}, \frac{1}{53}, \frac{19}{106}, \frac{3}{53}, \frac{3}{53}, \frac{2}{53}, \frac{3}{53}, \frac{1}{53}, \frac{7}{53}, \frac{7}{106}, \frac{2}{53}, \frac{5}{53}, \frac{9}{53}, \frac{10}{53}, \frac{1}{53}, \frac{5}{106},\right.$$
$$\frac{1}{106}, \frac{2}{53}, \frac{7}{53}, \frac{3}{106}, \frac{5}{106}, \frac{1}{106}, \frac{2}{53}, \frac{6}{53}, \frac{3}{106}, \frac{4}{53}, \frac{5}{106}, \frac{1}{53}, \frac{2}{53}, \frac{2}{53}, \frac{6}{53}, \frac{2}{53}, \frac{2}{53}, \frac{3}{106},$$
$$\frac{1}{106}, \frac{3}{53}, \frac{2}{53}, \frac{12}{53}, \frac{3}{53}, \frac{1}{53}, \frac{9}{53}, \frac{2}{53}, \frac{13}{53}, \frac{1}{53}, \frac{3}{53}, \frac{1}{106}, \frac{3}{53}, \frac{1}{106}, \frac{1}{106}, \frac{9}{106}, \frac{5}{106}, \frac{1}{53}, \frac{5}{53},$$
$$\frac{3}{106}, \frac{6}{53}, \frac{7}{106}, \frac{3}{106}, \frac{5}{106}, \frac{2}{53}, \frac{7}{106}, \frac{1}{53}, \frac{2}{53}, \frac{1}{53}, \frac{7}{106}, \frac{1}{53}, \frac{1}{106}, \frac{7}{106}, \frac{5}{106}, \frac{2}{53}, \frac{5}{106},$$
$$\frac{1}{106}, \frac{1}{106}, \frac{1}{106}, \frac{2}{53}, \frac{4}{53}, \frac{3}{53}, \frac{1}{53}, \frac{3}{53}, \frac{25}{106}, \frac{9}{53}, \frac{3}{106}, \frac{2}{53}, \frac{2}{53}, \frac{1}{106}, \frac{15}{106}, \frac{13}{106}, \frac{13}{53},$$
$$\left.\frac{5}{106}, \frac{1}{106}, \frac{7}{53}, \frac{1}{53}, \frac{2}{53}, \frac{5}{106}, \frac{5}{106}, \frac{18}{53}, \frac{11}{53}, \frac{2}{53}, \frac{7}{106}, \frac{3}{106}, \frac{4}{53}, \frac{1}{106}, \frac{1}{106}, \frac{2}{53}\right\}$$

==========

Betweenness centrality:

{0., 25.7243, 0., 0., 0., 0., 443.014, 3.49547, 223.235, 105., 3.38976, 0., 350.687,
8.55674, 0.583333, 26.3065, 272.161, 148.844, 0., 105., 0., 0.333333, 874.837, 0., 312.,
0., 0.333333, 107.635, 0., 35.1554, 16.6775, 0., 0., 0., 32.7217, 0.333333, 12.2081,
1.35026, 0., 0., 1., 556.185, 131.104, 0., 141.541, 2.2619, 1279.75, 3.20799,
12.9658, 0., 106.959, 0., 0., 21.0399, 3.67319, 0., 84.6723, 0., 40.4907, 6.10677,
0., 11.0869, 47.9072, 1.44137, 0., 3.47032, 0., 108.963, 0., 0., 6.40094, 4.65178,
0., 1.46667, 0., 0., 0., 0., 23.5284, 40.695, 0., 4.24405, 706.557, 1165.6, 0.,
1.46337, 0.375747, 0., 179.597, 78.8131, 705.199, 6.96958, 0., 571.525, 0., 2.62543,
10.7192, 3.88683, 1101.38, 364.721, 32.8242, 5.06089, 87.061, 18.2153, 0., 0., 0.}

==========

Closeness centrality:

{0.268354, 0.389706, 0.392593, 0.343042, 0.261728, 0.329193, 0.486239, 0.40613, 0.379928,
0.285714, 0.338658, 0.301136, 0.420635, 0.388278, 0.345277, 0.375887, 0.441667, 0.443515,
0.340836, 0.332288, 0.25, 0.270408, 0.365517, 0.334385, 0.332288, 0.339744, 0.270408,
0.46087, 0.329193, 0.370629, 0.369338, 0.341935, 0.333333, 0.33125, 0.403042, 0.330218,
0.338658, 0.31454, 0.222689, 0.352159, 0.270408, 0.479638, 0.395522, 0.335443, 0.439834,
0.313609, 0.479638, 0.345277, 0.288043, 0.25, 0.379928, 0.268354, 0.276042, 0.389706,
0.335443, 0.297753, 0.392593, 0.348684, 0.358108, 0.375887, 0.344156, 0.338658,
0.366782, 0.361775, 0.269036, 0.37193, 0.297753, 0.353333, 0.340836, 0.325153, 0.395522,
0.377224, 0.350993, 0.33125, 0.325153, 0.268354, 0.329193, 0.328173, 0.415686, 0.355705,
0.330218, 0.378571, 0.488479, 0.5, 0.344156, 0.358108, 0.312684, 0.25, 0.384058,
0.417323, 0.509615, 0.37193, 0.25, 0.479638, 0.326154, 0.373239, 0.361775, 0.349835,
0.512077, 0.469027, 0.373239, 0.355705, 0.37193, 0.369338, 0.325153, 0.268354, 0.328173}

==========

```
Eigenvector centrality:
 {0.000273884, 0.00637794, 0.0113192, 0.00238172, 0.00086063, 0.0029897, 0.0322144, 0.0149439,
  0.0059173, 0.000814607, 0.00727935, 0.00108148, 0.0166589, 0.0154592, 0.0089667,
  0.0119963, 0.0278149, 0.0356133, 0.00449446, 0.00270858, 0.000165049, 0.000421165,
  0.00361799, 0.00223712, 0.00218029, 0.00368254, 0.000421165, 0.0242196, 0.00236574,
  0.0105573, 0.011453, 0.00454317, 0.00536454, 0.00269415, 0.0233048, 0.00281457,
  0.00442589, 0.00415283, 0.0000616662, 0.0137311, 0.000360447, 0.0395458, 0.00643381,
  0.00478396, 0.0333317, 0.00248862, 0.0205842, 0.00343133, 0.00116397, 0.000205041,
  0.0127453, 0.000273884, 0.000964827, 0.0171824, 0.00552468, 0.00136437, 0.0164864,
  0.0070029, 0.00444431, 0.0134058, 0.00464962, 0.00393719, 0.00414663, 0.0165141,
  0.00030117, 0.00999329, 0.00136437, 0.0113689, 0.00435033, 0.00155824, 0.0160489,
  0.0108855, 0.00979539, 0.00283461, 0.00299363, 0.000273884, 0.00267836, 0.002282,
  0.0170107, 0.00418371, 0.00358648, 0.0117446, 0.035381, 0.0288412, 0.00464962, 0.00839288,
  0.00414801, 0.000165049, 0.00785246, 0.0239774, 0.0402852, 0.0107255, 0.000165049,
  0.0241598, 0.00189467, 0.00638676, 0.00739419, 0.00974791, 0.0486461, 0.032493,
  0.00452376, 0.0126442, 0.00427313, 0.0108981, 0.00299363, 0.000273884, 0.002282}

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page Rank centrality:
 {0.00315131, 0.00732898, 0.00547751, 0.00516212, 0.00268069, 0.00355316, 0.0220502, 0.0075869,
  0.0102019, 0.00906026, 0.00822235, 0.00393418, 0.0188688, 0.00857519, 0.00547145,
  0.0102324, 0.0211822, 0.0222873, 0.00359754, 0.00897165, 0.00368093, 0.00847967, 0.0288143,
  0.00519808, 0.0134063, 0.00241443, 0.00847967, 0.0139693, 0.00518222, 0.0102909,
  0.00678561, 0.00369325, 0.0056805, 0.00660523, 0.0139338, 0.00651253, 0.00622807,
  0.00459589, 0.00332717, 0.0072954, 0.00889808, 0.0287276, 0.00922724, 0.00342796,
  0.0203534, 0.00639244, 0.0358287, 0.00355489, 0.0115453, 0.00292705, 0.0086734,
  0.00315131, 0.0026306, 0.0110348, 0.00689271, 0.00443039, 0.0129452, 0.00468622,
  0.0180952, 0.00867734, 0.00486041, 0.00762577, 0.00717145, 0.00833433, 0.00504215,
  0.00547711, 0.00443039, 0.0105315, 0.00342513, 0.00257319, 0.00858097, 0.00660484,
  0.00544238, 0.0078838, 0.0024193, 0.00315131, 0.00242769, 0.00659705, 0.00974334,
  0.0100204, 0.00351488, 0.00777255, 0.0301711, 0.022292, 0.00486041, 0.00545569,
  0.00573338, 0.00368093, 0.0216197, 0.0148907, 0.0300097, 0.00695946, 0.00368093,
  0.0180201, 0.00385493, 0.00584573, 0.00678656, 0.00659096, 0.042885, 0.0257002,
  0.00632068, 0.00895818, 0.00558342, 0.0100336, 0.0024193, 0.00315131, 0.00659705}

================================================================
```

- We will present the graphs according to the big 7

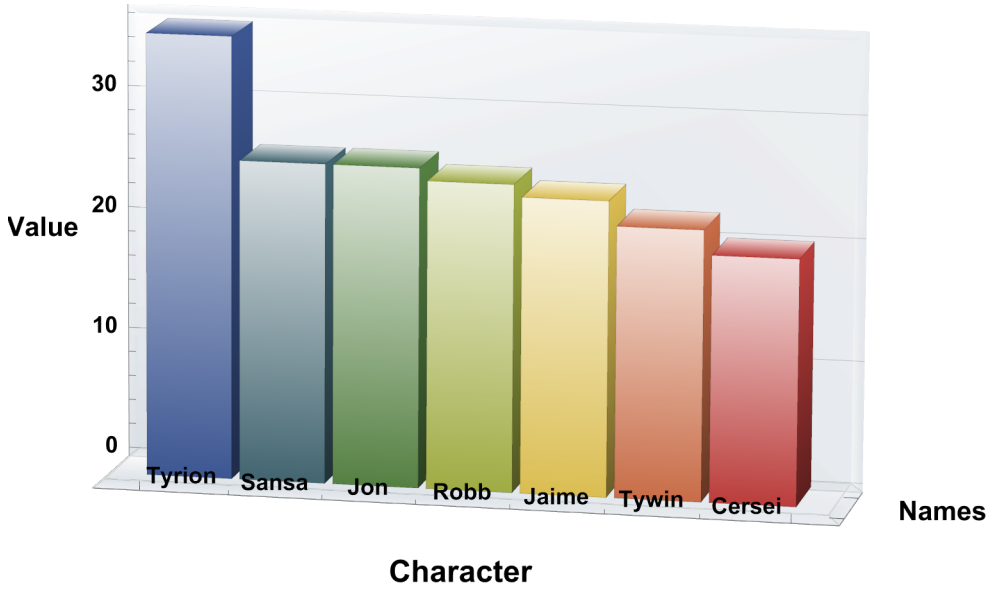
Degree centrality

In[215]:=

```
deg = Transpose[{Part[VertexList[T], Ordering[DegreeCentrality[T], 7, Greater]],
    Part[DegreeCentrality[T], Ordering[DegreeCentrality[T], 7, Greater]]}];

BarChart3D[deg[[All, 2]], ChartStyle → "DarkRainbow", ChartLabels → deg[[All, 1]],
 LabelStyle → {Directive[FontFamily → "Arial", FontSize → 12, Bold], Black},
 ImageSize → Medium, Boxed → False, AxesLabel →
  {Style["Character", Bold, 16], Style["Names", Bold, 14], Style["Value", Bold, 14]}]
```

Out[216]=



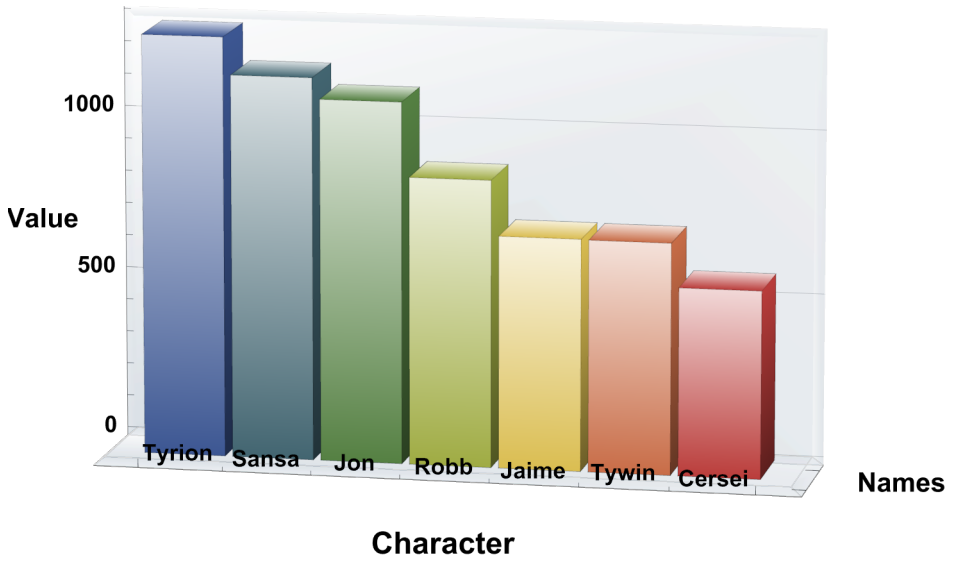
Betweenness centrality

In[217]:=

```
Bet = Transpose[{Part[VertexList[T], Ordering[BetweennessCentrality[T], 7, Greater]],
    Part[BetweennessCentrality[T], Ordering[BetweennessCentrality[T], 7, Greater]]}];

BarChart3D[Bet[[All, 2]], ChartStyle → "DarkRainbow", ChartLabels → deg[[All, 1]],
 LabelStyle → {Directive[FontFamily → "Arial", FontSize → 12, Bold], Black},
 ImageSize → Medium, Boxed → False, AxesLabel →
  {Style["Character", Bold, 16], Style["Names", Bold, 14], Style["Value", Bold, 14]}]
```

Out[218]=

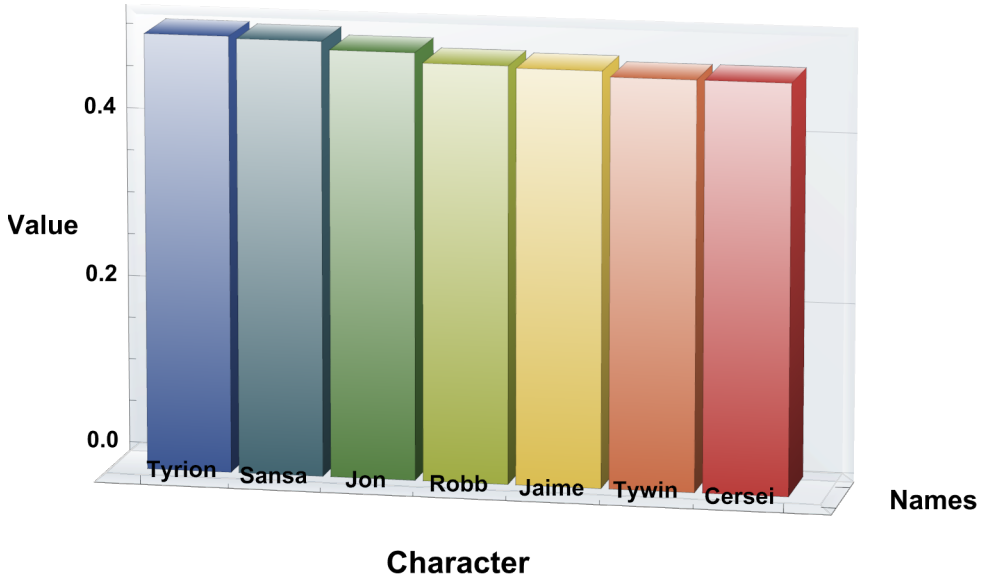


Closeness centrality

In[219]:=
```
Clos = Transpose[{Part[VertexList[T], Ordering[ClosenessCentrality[T], 7, Greater]],
    Part[ClosenessCentrality[T], Ordering[ClosenessCentrality[T], 7, Greater]]}];

BarChart3D[Clos[[All, 2]], ChartStyle → "DarkRainbow", ChartLabels → deg[[All, 1]],
 LabelStyle → {Directive[FontFamily → "Arial", FontSize → 12, Bold], Black},
 ImageSize → Medium, Boxed → False, AxesLabel →
  {Style["Character", Bold, 16], Style["Names", Bold, 14], Style["Value", Bold, 14]}]
```

Out[220]=



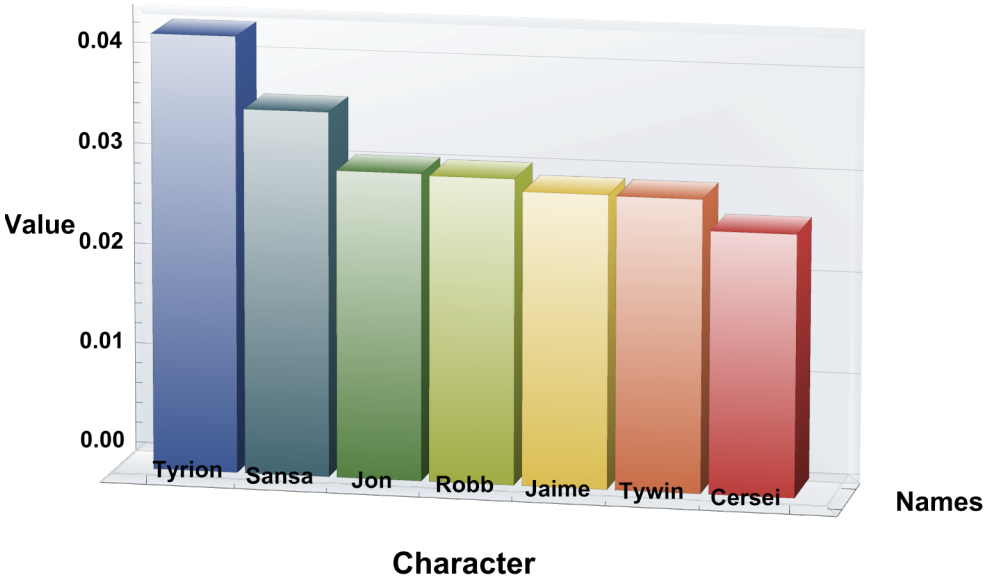
Page Rank Centrality

In[221]:=

```
Page = Transpose[{Part[VertexList[T], Ordering[PageRankCentrality[T], 7, Greater]],
    Part[PageRankCentrality[T], Ordering[PageRankCentrality[T], 7, Greater]]}];

BarChart3D[Page[[All, 2]], ChartStyle → "DarkRainbow", ChartLabels → deg[[All, 1]],
 LabelStyle → {Directive[FontFamily → "Arial", FontSize → 12, Bold], Black},
 ImageSize → Medium, Boxed → False, AxesLabel →
  {Style["Character", Bold, 16], Style["Names", Bold, 14], Style["Value", Bold, 14]}]
```

Out[222]=



Eigen Vector Centrality

In[223]:=

```
Eig = Transpose[{Part[VertexList[T], Ordering[EigenvectorCentrality[T], 7, Greater]],
    Part[EigenvectorCentrality[T], Ordering[EigenvectorCentrality[T], 7, Greater]]}];

BarChart3D[Eig[[All, 2]], ChartStyle → "DarkRainbow", ChartLabels → deg[[All, 1]],
 LabelStyle → {Directive[FontFamily → "Arial", FontSize → 12, Bold], Black},
 ImageSize → Medium, Boxed → False, AxesLabel →
  {Style["Character", Bold, 16], Style["Names", Bold, 14], Style["Value", Bold, 14]}]
```

Out[224]=