

When countries are clustered into three, the clusters have (26, 9, 1) and (24, 11, 1) countries for the years 2000 and 2015 respectively. Turkey and Poland have moved from the large cluster into the medium one. USA has been clustered “far” from other clusters as if it is an outlier because that cluster contains only USA. In clustering with four classes, countries are clustered as (24, 9, 2, 1) and (23, 10, 2, 1) for the years 2000 and 2015 respectively. The difference between $k=4$ and $k=3$ is that Germany and Japan have been clustered into separate classes. Moreover, for $k=4$, only Turkey has moved to another cluster between 2000 and 2015.

For $k=5$ clusters, the groupings are (23, 7, 3, 2, 1) and (23, 7, 4, 1, 1) for 2000 and 2015 respectively. The transitions between clusters are more than the other two cases. Germany and Japan are again clustered together in 2000 as a pair, but Germany returns to the cluster with 4 countries in 2015. Moreover, Korea and United Kingdom switch their clusters between 2000 and 2015.

In all cases of k -means clustering (also for larger k values of 6 and 9) USA is an outlier. Japan and Germany are clustered as a pair in 2000, however, Germany joins a larger cluster in 2015. There are only a few countries that observe a transfer between clusters: Turkey, Korea, Poland, UK, and for larger k values Greece and Spain also transfer between clusters.

For the SOM simulations, there are two plots to be considered. The first plot allows the visualization of the clusters

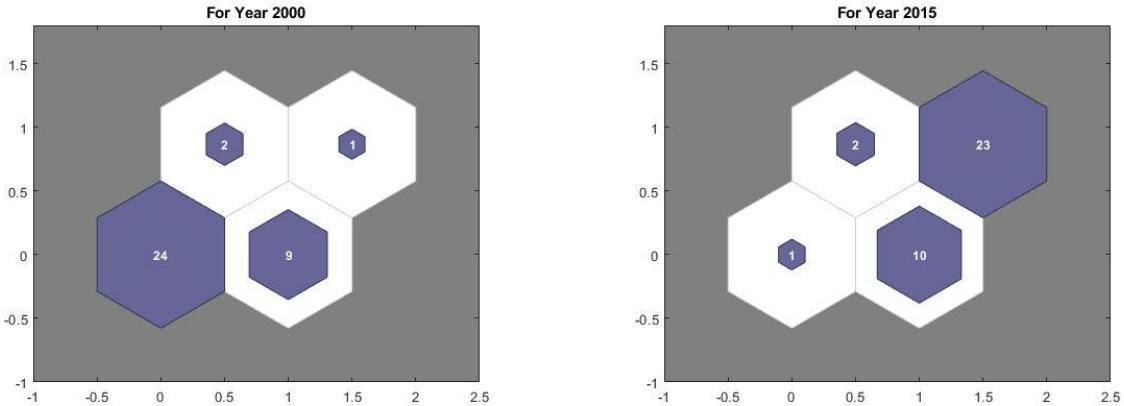


Fig. 1. 2-dim maps for 2x2 SOM displaying distribution (count of countries) and neighborhood of clusters.

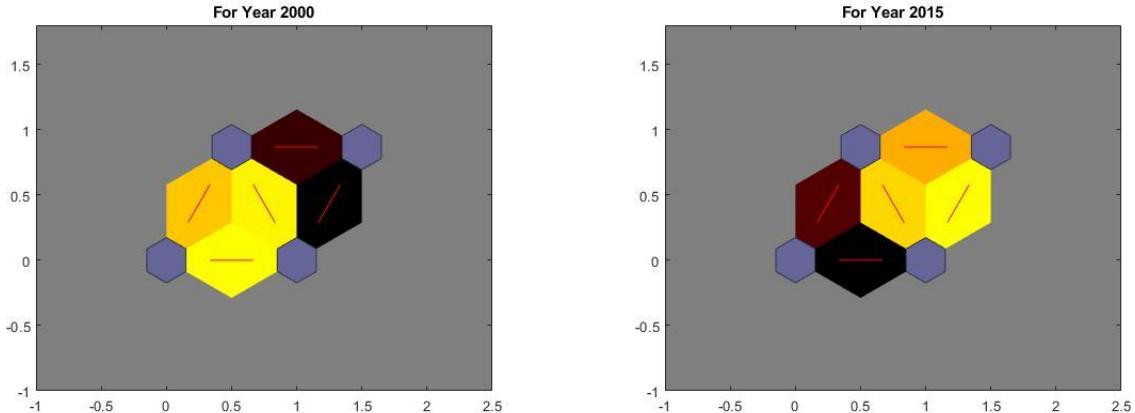


Fig. 2. Maps for 2x2 SOM displaying neighbor distances of clusters.

with their country counts on a 2-dimensional map. The outcomes for two exemplary runs of 2x2 SOM architecture (4 neurons) for the years 2000 and 2015 are given in Fig. 1. It is evident that the countries formed a large, a medium and two small clusters.

The second type of plot gives the distance between neighbor neurons on the map. Fig. 2 displays the neighbor distances for the 2x2 SOM mentioned above. The red lines identify the connection between neighbor neurons. The colors of regions containing the lines represent the distances between neurons. The darker colors (black and brown) express a larger distance between two neighbor neurons while the lighter colors (orange and yellow) express a smaller distance. By looking at the distance between neighboring neurons in the SOM, the amount of the similarity between the data of two different neighboring clusters can be determined. As the distance between the two adjacent neurons decreases, the similarities of the clusters represented by these two neurons increase. In the same way, the similarity between the instances of two clusters decreases as the distance between them increases. In this study, similarities of the neighbor clusters in the SOM were examined further. According to the results of neighboring distances, the close sets of neighboring clusters are merged and a new, enhanced level of clustering is performed.

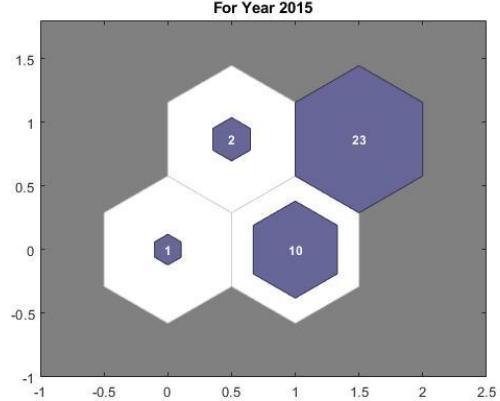


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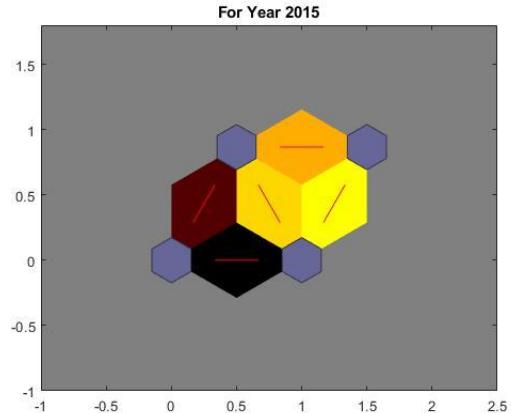


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