Transformation of an Esvecees (SVCS) Value to Spherical Coordinates as the Result of the Earthquake Forecasting Using SLHGN

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Abstract. The main issue, which has existed since the development of Single Layer Hierarchical Graph Neuron (SLHGN) started, is the representation for location data that will be fed to SLHGN structure. Similar issue, the double-value characteristics of the ordinary and current coordinate system have slowed down the enhancement of a sophisticated earthquake forecasting technology that uses SLHGN. To deal with the problem, a new way of representing locations on the earth, called Single Value Coordinate System (SVCS), has been researched and developed. Since the location of a potential earthquake—after being elaborated by the earthquake forecaster—is represented through esvecees (SVCS) values, people would have difficulties to understand and to locate it. To make the earthquake forecasting results be understandable and locatable for targeted people, those esvecees values should therefore be transformed into ordinary coordinates, which comprise longitude and latitude values. For that purpose, a technology for the transformation from esvecees values to ordinary coordinates have been successfully developed. The experiment results show that the location of a potential earthquake can now be gained as longitude and latitude values. This means that the earthquake forecasting using Single Layer Hierarchical Graph Neuron (SLHGN) is getting closer to its complete functionalities.

Keywords: Earthquake Forecasting · Single Layer Hierarchical Graph Neuron (SLHGN) · Single Value Coordinate System (SVCS) · Hierarchical Graph Neuron (HGN)

1 Introduction

It is required that an earthquake forecasting technology should be intelligent enough to generate information about not only the magnitude of the upcoming earthquake but also the time it will occur, and where the location will be. To support such an intelligent capability of the forecaster, our current earthquake forecaster utilizes the Single Layer Hierarchical Graph Neuron (SLHGN). This technology is a relatively new artificial intelligence developed since five years ago.

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The artificial intelligence plays the main role for forecasting the magnitude, the time, and the location of a future earthquake. For this purpose, the SLHGN needs to acquire appropriate data that will be distributed to the entire elements of SLHGN. The data must therefore be sufficient and thorough. In fact, the data must contain the time-series of prior earthquakes that generally build some kind of patterns of magnitudes, time, and locations.

The patterns that are elaborated within the architecture of SLHGN are similar to multidimensional patterns. However, since the data is gathered from the whole surface of the earth, the dimensionality of the SLHGN structure is quite unique. The earthquake data should consists of spherical-shaped data that is acquired within regular time interval, and every area of the earth surface should provide with the magnitude of an earthquake.

There are some important issues related to the earthquake data, which is available for free, for instance the data provided by USGS. The location data contains two values of longitude and latitude, and the unit of both values are normally in degree. Typically, a small difference of the longitude or latitude value would not affect the cosine value of it. Moreover, the value are in floating point type, which may cost a lot of CPU-cycle while processing it. These are the beginning indications that the current coordinate system seems to be problematic for earthquake forecasting technologies.

Some other issues related to the current coordinate system lies in the natural shape of the earth, which is a sphere. A coordinate on a spherical shape does not show an area, but a point. Even though the coordinate of a point is known, it is still difficult to pinpoint it on the earth surface without a satellite support. Although it is not always straightforward [1]. Some researchers [2, 3, 4] have identified other problems in relation to spherical characteristic of the earth. Usually, the current coordinate system is converted to a 2D map. However, the conversion seems to be problematic as well [5, 6], as it may deteriorate the preciseness of the longitude and the latitude values on the map. As the effect, the distance between two points on the map cannot be so precise either, in particular on the pole areas.

On the other hand, the currently under development earthquake forecaster produces a location which pinpoints an area, rather than a point. The reason to this is that it is difficult for the technology to forecast the point of a location. Furthermore, it is very unlikely, that the same and exact point of a previous earthquake would become the epicenter of the next earthquake. Rather, an earthquake could be forecasted to occur on an area. Such an area would cover particular part of the earth crust. Up to this point of our research, the smallest area size that can be represented by the esvecees technology is within four square meters.

The location of a forecasted earthquake generated by the SLHGN has been named as single value coordinate system (SVCS), or simply esvecees. The esvecees treats the South Pole area of the earth surface as the reference area or a starting area. Different to the current one, the value of esvecees is always scalar, and everywhere on the earth surface the value of esvecees holds the same preciseness. Esvecees technology is hierarchical. It means that the length of the esvecees value represents the depth of the hierarchy. The longer the value, the smaller the area the esvecees value represents.

Esvecees technology can be extended for bigger spheres by increasing the radius size. Even though the radius size will not affect the value of esvecees itself. Just the height of the reference area needs to be moved further from or closer to the earth center. Therefore, the technology can be used for representing a location outside the earth. The esvecees technology is not just for representing the location of an area, but it can also be utilized for representing the direction from one area to another area.

As people are already used to the current coordinate system containing longitude and latitude values, it would be difficult for them to elaborate the information produced by the earthquake forecaster, when the location of the forecasted earthquake is represented through the esvecees value technology. It is therefore straightforward, that the transformation approach from an esvecees value to the current coordinate system is required. Other researchers [7, 8, 4] have also tried some kind of transformation such as using matrix, but different to esvecees conversion that uses a single value. It is also expected that the transformation approach should be consistent, wherever location the earthquake would be. By having such a transformation approach, the process of our earthquake forecasting system using SLHGN would produce effective and useful results.

2 Earthquake Forecasting Results

When an earthquake forecasting technology can work with a high accuracy, its support will possibly reduce damages and casualties in the end. By having the forecasting results very early, for instance ten hours prior to the shock hit, people may have an opportunity to be evacuated or at least to find a safe heaven where they will be protected from the furious side effects. When there is still some time available, some important belongings can also be protected or moved to a safe area as well. Such a scenario has been attempted as an approach for the earthquake risk reduction campaign for a long time, but no satisfactory results found yet.

The technology for earthquake forecasting—developed in our research—produces results that forecast not only the magnitude but also the location and the time of the earthquake. It seems to be that the magnitude is the most important parameter to be known by citizen, but the time of the occurrence and the location are as important as the magnitude. People need to know the location of the forecasting through which people can figure out whether their location is under threat or not. If the nearby location is the forecasted area, people also need to know how long they have time left for the evacuation process or for finding a safe heaven.

Our current forecasting technology produces the forecasted location using Single Value Coordinate System (SVCS) technology, simply called esvecees. This technology represent the location of an upcoming earthquake not as a point but as an area. Such a new approach would not be understandable for people for finding the location as they are not used to it. It is therefore important that the esvecees value must be transformed to the common and current coordinate system containing longitude and latitude values, prior to the submission of it publicly.

The core engine that produces the esvecees value is the SLHGN. The technology will produce an area as the result of the forecasting process. The area can be a triangle, a tetragon, a pentagon, or a hexagon. It is required that when the SLHGN produces an area as its result, it should be transformed to a number of longitude and latitude value pairs. For instance, if the result represents a pentagon area, the transformation will produce an array of five value pairs of longitude and latitude.

When the forecasted esvecees value has been transformed to longitude and latitude values, through which the effectiveness of the mobility of people and goods during the evacuation process can be increased. It is therefore important to ensure that the transformation process should have very high accuracies and preciseness. One prerequisite to achieve it is that the earthquake forecaster should produce of high accuracy and precise forecasted areas.

3 Forecasting Steps of SLHGN

The usual thing people might be interested in an earthquake forecasting technology is about when and how big an earthquake might occur in the area and its surroundings. Based on the results of the previous research on SLHGN it is shown that the SLHGN has an ability to recognize an earthquake about nine hours earlier. This should give them ample time for the evacuation process. So, people might change their thoughts to the following. In relation to an earthquake, what would happen in my place and its surroundings in nine hours' time? Such a question is actually the first part within the forecasting process using the SLHGN.

After the area and the timestamp has been determined, the next part of the forecasting process is the collection of the earthquake magnitudes from all areas across the earth surface which occurred in the last hour (the historical data). The process of the collection continues for historical data of the last two hours, three hours, up to the last eighty one hours. All the data will then be fed to the SLHGN structure. Bear in mind that the location of each earthquake (containing longitude and latitude values) must first be transformed to an esvecees value before being fed to the SLHGN. The approach of transforming a coordinate (two values) to an esvecees value will be discussed in another publication paper.

Following the nature of the earth, all the historical data is clustered within thirty two areas. Similarly, all the historical data is clustered within eighty-one-hour time-frames. This means that for instance all the earthquakes occurred between 09.00 and 10.00 o'clock will be regarded as within the same time cluster. The reason to this is based on the previous research that SLHGN has an ability to recognize only 90% of complete patterns with more than 92% accuracy.

With such an ability, the earthquake forecaster should be able to forecast an earthquake nine hours earlier. In case all the data collected, instead of eighty-one-hour time-frames, comprising only eighty-hour time-frames the SLHGN would still have a capability to forecast earthquakes. With such a condition the SLHGN can forecast an earthquake even for the next ten hours. Although such a capability of SLHGN exists and seems to be more useful, the accuracy of the forecasting capability will be less than 92%. Further, in case all the data collected only covers seventy-nine-hour time-frames, the SLHGN would still have a capability to forecast earthquakes in the next eleven hours, but with an accuracy of even lesser than 92%.

Similarly, not only in terms of the number of time-frames, the SLHGN can also be used to forecast an earthquake using a wider time frame, not hourly-based but daily-based or even weekly-based [9, 10]. But, it is logical that the accuracy would be lesser the wider the time frame would be. In case the time frame is daily-based, the historical data must be added up within a day. Similarly, when the time frame is weekly-based, the historical data must be added up within a week.

The added up earthquake magnitudes within hourly-based time frame along ninety eighty nine hours will generate a two-dimensional pattern. Since the pattern is built from every esvecees value (location), then it will generate a three-dimensional pattern. Because the architecture of SLHGN is hierarchical, the entire architecture will require four-dimensional patterns. Imagine that there are 32 polygons areas (12 pentagons and 20 hexagon) on the earth. The number of nodes within the SLHGN are 32 as well. In the layer on top of that, there are 12 nodes. The hierarchy continues to 6 and 2 nodes on the upper layers and finally on the top, there is only one single node. So, the hierarchy order is the following: 1, 2, 6, 21, and 32. In case the SLHGN requires to scrutinize patterns deeper, the hierarchy order would be: 1, 2, 6, 21, 32, 180, 360, and so on.

When the pattern has been completely built, it will be elaborated within the SLHGN architecture to be recognized. Assume that the SLHGN has properly been trained, so it means that when the current pattern has already been stored within SLHGN during the training session, the current pattern would be recognized by the SLHGN. Although the current pattern is only 90% (eighty-one-hour time-frames) of a trained pattern (ninety-hour time-frames) stored within the SLHGN architecture, the accuracy of producing correct results would be more than 92%.

The result of the forecasting process will contain earthquake magnitudes on 12 pentagons and 20 hexagons on the earth surface. The number of polygons depends on the setup architecture of the SLHGN. It can also be setup for 180 polygons, 360 polygons, and so on. From the result it can be figured out in which area the process will be focused on. Again, the result area can be a triangle, a tetragon, a pentagon, or a hexagon. However, after the seventh layer down from the top of the hierarchy the area is always a triangle. Since the result represents esvecees values, before being disseminated publicly, the esvecees values must be transformed to common coordinates that contain longitudes and latitudes.

4 Transformation of Esvecees Values to Spherical Coordinates

Before discussing the transformation process, it is important to describe the esvecees value first. As already mentioned, a coordinate depicted using the esvecees technology contains one single value only. The following are some samples of esvecees values.

```
Santiago(-70.6693, -33.4489)→   0:e>1>a903232001123123201l
London(-0.1278, 51.5074)→       0:a>13312>f100001020030132300003 01
Nairobi(36.8219, -1.2921)→      0:b>12>f41101321120012021200 2
Tiksi(128.8645, 71.6375)→       0:c>13312>f352312233203022210 3
Anchorage(-149.9003, 61.2181)→  0:d>13312>f37211113212233003211 1
Wellington(174.7787, -41.2924)→ 0:d>>f363220302220213031l3
```

From the samples above, an esvecees value always starts with a zero followed by a delimiter, a colon. The two bigger signs are also delimiters. The zero means that the esvecees value uses the lowest level of earth areas in which there are 20 hexagons and 12 pentagons on the earth surface. The following figure shows them (Fig. 1).

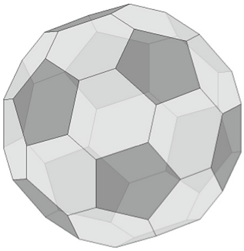

Fig. 1. The truncated icosahedron

If the esvecees value uses the next level (level 1) of the earth areas, there will be 120 hexagons and 12 pentagons (depicted in the figure below). However, for simplicity until the rest of the paper the discussion will always refer to level 0 of the earth area (Fig. 2).

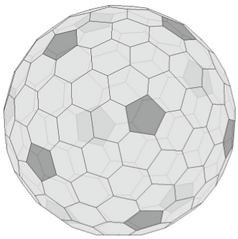

Fig. 2. Another type of a football with 120 hexagons and 12 pentagons

The following figure shows all the 20 hexagons and 12 pentagons represented on a two dimensional format (Fig. 3).

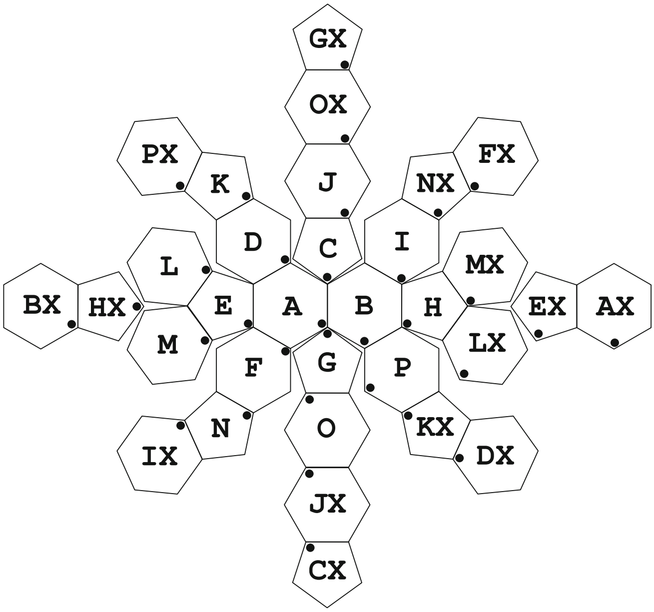

Fig. 3. The two-dimensional representation of a truncated icosahedron

In the esvecees technology, the pentagon G is chosen as the starting area of every esvecees value, and the South Pole is chosen as the starting point of every esvecees value. Why it is called as the starting point, because an esvecees value in principle represents a direction. From the South Pole, the letter after the colon shows the first direction. For instance, the esvecees value of the city of Anchorage has a letter d. The following shows all the letters on the pentagon G and the hexagon A (Fig. 4).

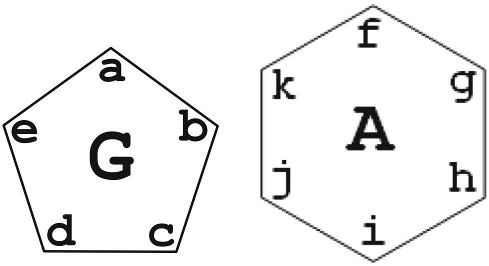

Fig. 4. The identities of corners within a pentagon and a hexagon

Note that in two dimensional format of the polygons, each of the corner a in a pentagon and the corner f in a hexagon are marked with a black dot. It can be seen from the previous data above that the esvecees value of Anchorage goes from the center of pentagon G through the corner d, about the same direction as the south-west. After going through the corner d, the next directions are: 1, 3, 3, 1, and 2. The following figure shows the meaning of those directions of 1, 2, and 3 (Fig. 5).

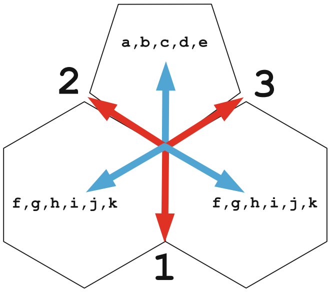

Fig. 5. The directions of 1, 2, and 3 on level 0 of earth surface

When the esvecees value represents a location/direction on level 1 of the earth surface, the following are some of the polygons including their indices (Fig. 6).

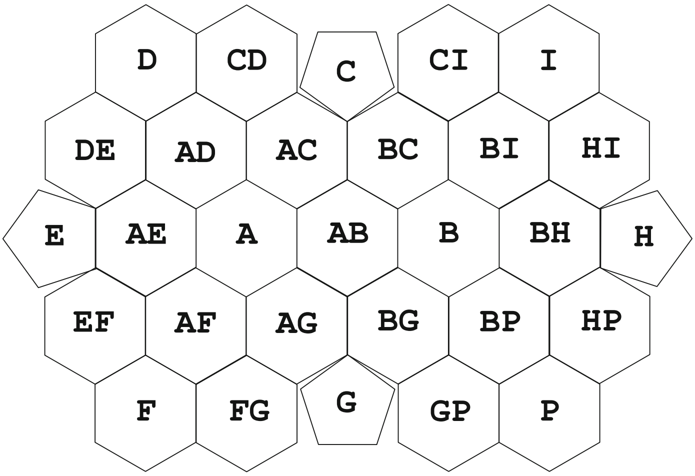

Fig. 6. The decomposition of the two-dimensional representation of a truncated icosahedron

The following are some samples of esvecees values on level 1 of the earth surface.

A →	1:a>15>f
B →	1:b>16>f
C →	1:a>15665>a
D →	1:a>156565>f
E →	1:e>16556>a
F →	1:e>15>f
G →	1:>>
H →	1:b>16556>a
I →	1:b>156565>f
P →	1:c>15>f

The following figure shows the meaning of those additional directions of 4, 5, and 6 (Fig. 7).

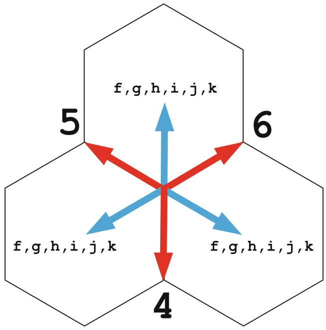

Fig. 7. Additional directions of 4, 5, and 6 on level 1 of earth surface

After the Anchorage's directions of 1, 3, 3, 1, and 2, the next direction is the letter f. It means that the direction goes into a hexagon through the corner f. After this point, the direction goes to one of the subareas of the hexagon. The direction to a subarea goes further, deeper, and deeper. The depth of the direction depends on how many digits the esvecees value would be needed. The following shows the subareas of each the pentagon and the hexagon with their corresponding indices (Fig. 8).

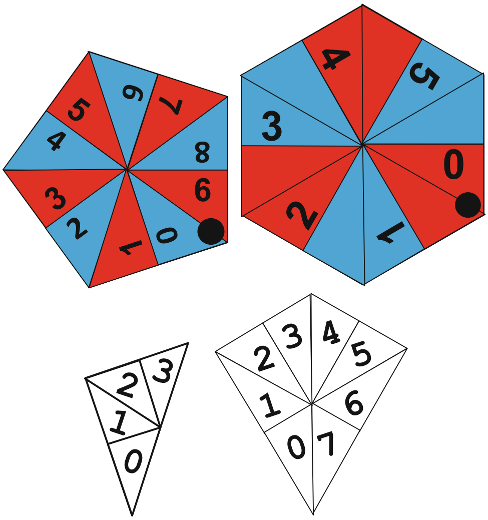

Fig. 8. The subareas within a pentagon, a hexagon, a triangle, and a tetragon

4.1 Generating Spherical Longitudes and Latitudes

The process of generating the values of longitude and latitude from those directions in an esvecees value follows the nature of the earth shape, which is a sphere. For every change of the directions, the longitude and the latitude will be calculated. In order to calculate those values, some formula have been composed through utilizing the formula of a truncated icosahedron, which contains 20 hexagons and 12 pentagons. The following are some elements within a pentagon and a hexagon that will be required in some formula (Fig. 9).

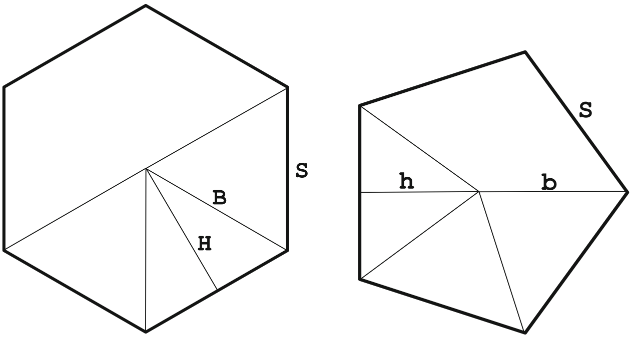

Fig. 9. The elements of a hexagon (H, B, S), and of a pentagon (h, b, S) in an icosahedron

Within a sphere, the identities of elements are appended with a letter c, stands for "curved". They are: Hc, Bc, Sc, hc, and bc. The following are those sphere elements including their positions (Fig. 10).

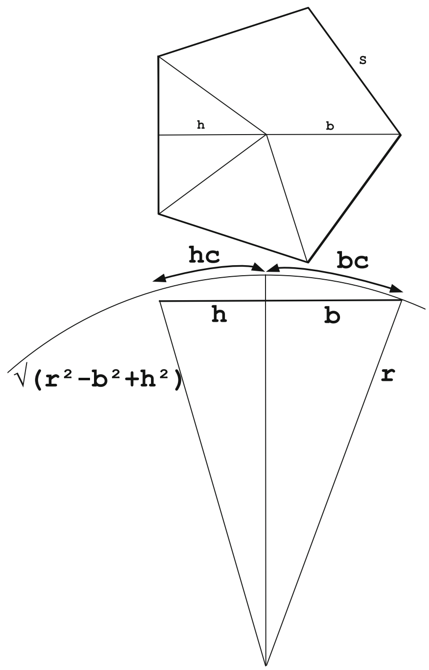

Fig. 10. Relationship between pentagon (h, b, S) of an icosahedron and of a ball (hc, bc, Sc)

When the directions go through the side of a polygon (a pentagon or a hexagon), the calculation of the side (S) length and its angle is required. Based on several resources [11–15], the following are the formulas for calculating S and Sc including their dependency to the radius (r).

$$S = \frac{4r}{\sqrt{58 + 18\sqrt{5}}} = 0.40354821233519766 * r$$

$$Sc = \frac{1}{2} d\theta, since\theta = 2\arcsin\left(\frac{S}{2r}\right), \text{then}$$

$$\text{Sc} = d * arcsin\left(\frac{2}{\sqrt{58 + 18\sqrt{5}}}\right) = 0.40633789992522046 * \text{r}$$

Similarly, when the directions go inside a polygon (a pentagon or a hexagon), the calculation of other elements of: B, Bc, H, Hc, b, bc, h, hc and their angles are required as well. The following are the formulas used for calculating them including their interdependency.

$$S = 2 * r * sin\left(\frac{Sc}{2 * r}\right)$$

$$B = S$$

$$H = 0.86602540378443864676372317075294 * S$$

$$Bc = arcsin\left(\frac{B}{r}\right) * r$$

$$Hc = arcsin\left(\frac{H}{\sqrt{r^2 - B^2 + H^2}}\right) * r$$

$$b = 0.85065080835203993218154049706301 * S$$

$$h = 0.68819096023558676910360479095544 * S$$

$$bc = arcsin\left(\frac{b}{r}\right) * r$$

$$hc = arcsin\left(\frac{h}{\sqrt{r^2 - b[i]^2 + h[i]^2}}\right) * r$$

After the description of all formulas of the curves, for calculating the latitude and the longitude of the point N (the closest point to the North Pole) the following are the formulas when the latitude and the longitude of two arbitrary points A and B, and the distance d between A and B are known.

$$\alpha_A = arctan\left(\frac{cos(\varphi_A) * cos(\varphi_B) * sin(\lambda_B - \lambda_A)}{sin(\varphi_B) - sin(\varphi_A) * cos(d)}\right)$$

$$\boldsymbol{\varphi_N = arccos\left(sin|\alpha_A| * cos(\varphi_A)\right)}$$

$$\boldsymbol{\lambda_N = \lambda_A + sign(\alpha_A) * \left|arccos\left(\frac{tan(\varphi_A)}{tan(\varphi_N)}\right)\right|}$$

On the other hand, it is important to note that every curve on the earth surface except for meridians and the equator is an orthodrome. Imagine that every orthodrome can pass two points, let say N and Y. The point N is the point from which the distance to the North Pole is the closest and the course angle on the point is the right angle (90°), and the point Y is an arbitrary point. Having all those values, it is required to calculate the latitude (φ) and the longitude (λ) of the point Y when the latitude, the longitude of the point N, and the angle (α) (to the meridian) of the curve with length (d) are known. For that purposes, the following are a number of formulas and equations required. Most of them are described and derived from [15] and [14].

$$tan(\varphi_Y) = tan(\varphi_N) * cos(\lambda_Y - \lambda_N)$$

$$\boldsymbol{\varphi_Y = arctan\left[tan(\varphi_N) * cos(\lambda_Y - \lambda_N)\right]}$$

$$cos(\lambda_Y - \lambda_N) = \frac{tan(\varphi_Y)}{tan(\varphi_N)}$$

$$\boldsymbol{\varphi_Y = arcsin\left[cos(d) * sin(\varphi_N)\right]}$$

$$\boldsymbol{d = arccos\left[\frac{sin(\varphi_Y)}{sin(\varphi_N)}\right]}$$

As $cos(\lambda_Y - \lambda_N) = \frac{tan(\varphi_Y)}{tan(\varphi_N)}$, or $cos(\lambda_N - \lambda_Y) = \frac{tan(\varphi_Y)}{tan(\varphi_N)}$

Then $\lambda_Y = \lambda_N \pm arccos\left(\frac{tan(\varphi_Y)}{tan(\varphi_N)}\right)$

$$\boldsymbol{\lambda_Y = \lambda_N \pm arccos\left\{\frac{tan\left[arcsin\left(cos(d) * sin(\varphi_N)\right)\right]}{tan(\varphi_N)}\right\}}$$

Already mentioned above, that the index of the last digit of an esvecees value represents a triangle. It is chosen that the coordinate of a triangle is its middle point. For revealing the longitude and the latitude of the middle point it is therefore required to scrutinize the characteristics of a spherical triangle. The following are the formulas for calculating an angle of a spherical triangle, which consists of three points: A, B, and C. On each point, there are angles of: α on A, β on B, and γ on C, and on the opposite of each point there are sides: a, b, and c.

$$\alpha = 2 * arctan\left(\frac{k}{sin(s-a)}\right)$$

$$\beta = 2 * arctan\left(\frac{k}{sin(s-b)}\right)$$

$$\gamma = 2 * arctan\left(\frac{k}{sin(s-c)}\right)$$

$$k = \sqrt{\left(\frac{sin(s-a) * sin(s-b) * sin(s-c)}{sin(s)}\right)}$$

$$s = \frac{a+b+c}{2}$$

5 Experiment Results

The following are the results taken during the experiment. The coordinates of six cities have been chosen as samples for the transformation of esvecees values to ordinary coordinates.

```
Santiago(-70.6693, -33.4489)→ 0:e>1>a9032320011231232011
Result: -70.66929962828182,-33.44889416566708

London(-0.1278, 51.5074)→ 0:a>13312>f1000010200301323000O301
Result: -0.15257098140401332, 52.46151273060408

Nairobi(36.8219, -1.2921)→ 0:b>12>f4110132112001202120O2
Result: 36.55162382776878, -7.97391061089416l

Tiksi(128.8645, 71.6375)→ 0:c>13312>f3523122332030222103
Result: 128.86454164229366, 71.63750357080748

Anchorage(-149.9003, 61.2181)→ 0:d>13312>f3721111321223300321l1
Result: 138.71224684080312, 57.4453923345578

Wellington(174.7787, -41.2924)→ 0:d>>f363220302220213031l3
Result: 174.52800656325064, -43.99688962860224
```

After the transformation, some values are not the same as their original coordinates. The reason to this is due to two factors: 1) some coordinates are on the border of an area, 2) some coordinates are in the area of the North Pole or the South Pole. For these two problems more solutions need to be found.

6 Conclusion

The capability of the Single Layer Hierarchical Graph Neuron (SLHGN) in forecasting a future earthquake would not be useful because the results of the forecasting are represented using Single Value Coordinate System (SVCS) values, or simply called esvecees values. Not many people have understood the technology of esvecees, and only some people with of very informed technology might have read and understood it. However, it has been elaborated and tested that an esvecees value can successfully be transformed back to the ordinary coordinates, which contain longitude and latitude values. With the transformation technology from an esvecees value to longitude and latitude, not only the forecasting technology would gain benefit from it, other purposes such as GPS, distance and routing application would find the transformation useful. Having all these successful results the aim for having a better earthquake forecaster looks promising.

References

1. McCarthy, J.J., Rowton, S., Moore, D., Pavlis, D.E., Luthcke, S.B., Tsaoussi, L.S.: GEODYN Systems Description Volume 1, Greenbelt: NASA GSFC (2015)
2. Jekeli, C.: Geometric Refernce System in Geodesy. Ohio State University, Columbus (2006)
3. Panou, G., Korakitis, R.: Geodesic equations and their numerical solution in Cartesian coordinates on a triaxial elipsoid. J. Geod. Sci. **9**(1), 31–42 (2017)
4. Engel, A.: Coordinate transformation algorithms for the hand-over of targets between POEMS interrogators. Eurocontrol, Brussel (2005)

5. Claessens, S.J.: Efficient transformation from Cartesian to geodetic coordinates. Comput. Geosci. **133**(1), 1–32 (2019)
6. ugli Abdufattakhov, H.M.: Coordinate systems and heights in geodesy. Eur. J. Res. Dev. Sustain. (EJRDS) **2**(11), 16–18 (2021)
7. Grewal, M.S., Weill, L.R., Andrews, A.P.: Global Positioning Systems, Inertial Navigation, and Integration. Wiley, Hoboken (2007)
8. Zeng, H.: Explicitly computing geodetic coordinates from Cartesian coordinates. Earth Planets Space **65**(4), 291–298 (2012). https://doi.org/10.5047/eps.2012.09.009
9. Nasution, B.B.: Features of single value coordinate system (SVCS) for earthquake forecasting using single layer hierarchical graph neuron (SLHGN). In: 2021 International Conference on Software Engineering & Computer Systems and 4th International Conference on Computational Science and Information Management (ICSECS-ICOCSIM), Pekan, Malaysia (2021)
10. Nasution, B.B., Sembiring, R.W., Siregar, I., Seri, E., Mardi, R.W.: Towards single value coordinate system (SVCS) for earthquake forecasting using single layer hierarchical graph neuron (SLHGN). In: Murayama, Y., Velev, D., Zlateva, P. (eds.) ITDRR 2020. IAICT, vol. 622, pp. 73–89. Springer, Cham (2021). https://doi.org/10.1007/978-3-030-81469-4_7
11. Bouman, J., Ebbing, J., Schmidt, M., Lieb, V., Fuchs, M.: Algorithm Theoretical Basis Document. GOCE+ GeoExplore, Munich (2015)
12. Badan Standardisasi Nasional: Geographic Information—Spatial Referencing by Coordinates. Badan Standardisasi Nasional, Jakarta (2011)
13. Ashby, N.: An Earth-Based Coordinate Clock Network, Boulder. National Bureau of Standards, Colorado (1975)
14. Fine, H.B., Thompson, H.D.: Coordintae Geometry. Macmillan Company, New York (1911)
15. Bronshtein, I., Semendyayev, K., Musiol, G., Muehlig, H.: Handbook of Mathematics. Springer, Berlin (2007). https://doi.org/10.1007/978-3-540-72122-2