Journal of Mathematics, Computations, and Statistics
Vol. 8. No. 1, April 2025 (pp. 259-269)
https://journal.unm.ac.id/index.php/JMATHCOS
P-ISSN: 2476-9487 E-ISSN: 2721-0863
DOI. 10.35580/jmathcos.v8i1.7843
Received:*11-03-2025* | ***Accepted:*** *30-04-2025* | ***Published:*** *30-04-2025*

Mathematics and Culture: Affine Transformation Representation of Atakkae Traditional House in Wajo Regency Using Blender Software

Ja'faruddin[1,*], Wen Haw Chen[2] Whennie Youngger Oeitama[1], Andi Ismudiah Padasasih[1], Widhi Kesawa Wijayana[1], Murnianti[1], Nurul Qalbi Rahman[1], and Indah Tri Wira Utami[1]

[1]*Universitas Negeri Makassar, Indonesia*
[2]*Tunghai University, Taiwan*

[*]Correspondent author: [a)] jafaruddin@unm.ac.id

Abstract*. This study examines the application of affine transformations to the geometric structure of the Atakkae traditional house in Wajo Regency, South Sulawesi, in the context of ethnomathematics. This traditional house, known as Saoraja La Tenri Bali, is a typical Bugis stilt house with architectural uniqueness in the form of 101 pillars and large dimensions. Affine transformations were used to analyze the geometric elements of this traditional house, including scale, rotation and shear, in order to understand the mathematical relationships in traditional design. This research used a descriptive qualitative approach with data collected through direct observation and literature review. Geometric visualization was conducted using Blender software, which utilizes matrix transformation to model the structure of the traditional house in detail. The results show that the geometric elements in Atakkae traditional houses reflect a combination of local wisdom and mathematical principles, which are relevant in preserving culture while providing new insights into the relationship between mathematics and tradition. The findings are expected to contribute to the documentation of cultural heritage and the development of ethnomathematics learning.*
Keywords: *ethnomathematics; affine transformation; atakkae traditional house; geometry; blender software.*

INTRODUCTION

Mathematics is a global topic that each culture has a conception of numbers and a theory that states that 1+1=2, regardless of how advanced the technology is (Riswati et al., 2021). This knowledge is not only found in schools and universities, but is also present in daily human activities (Chen & Ja'faruddin, 2021). When humans interact to fulfill their needs, various problems will arise, so solutions are needed to overcome them. Mathematics as a communication tool is present to solve human problems at that time (Siregar & Dewi, 2022). This shows how important mathematics is in people's lives despite its development from time to time (Jafaruddin & Chen, 2023).

Culture is a tradition that has been passed down from generation to generation. Culture is what shows a custom or tradition of the area. Culture is closely related to society (Sihite et al., 2022). Culture is defined as all things related to culture (Putri, 2017). This means that whatever the name, type or content of a community habit related to culture can be called culture (Sulistyani et al., 2019). In every culture, there are important concepts of science that can be interpreted, for example the concept of mathematics (Ja'faruddin & Naufal, 2023; Laukum et al., 2024).

The relationship between culture and mathematics is known as ethnomathematics (Jafaruddin & Chen, 2023). Linguistically, the prefix "ethno" is defined as something very broad that refers to the socio-cultural context, including language, behavioral codes, myths and symbols. The root word "mathema" tends to mean explaining, knowing, understanding, and performing activities such as coding, measuring, classifying, inferring, and modeling. The suffix "tics" comes from techne, and means the same as technique (Pratiwi & Pujiastuti, 2020). In the explanation above, culture is tied to mathematics which requires knowledge of measurement, counting and so on. For example, in making a traditional house there must be a calculation and measurement so that the traditional house is as desired (Susanto et al., 2022).

One example is the Atakkae traditional house located in the traditional house area of Atakkae Village, Tempe District, Wajo Regency, South Sulawesi. In this traditional house area, there is the largest traditional house and the main traditional house. This traditional house is called "Saoraja La Tenri Bali" or in Indonesian known as La Tenri Bali Palace. It is called so because this palace was once the place of power of a king named La Tenri Bali (Tokang et al., 2023). In the design of this Atakkae traditional house, there are elements of geometry that represent local wisdom and cultural aesthetics (Ja'faruddin & Naufal, 2023).

To analyze the shape and structure of this traditional house, researchers used affine transformation. The affine transformation is a type of linear transformation that transforms two-dimensional coordinates into other two-dimensional coordinates through a series of sub-transformations, such as translation, rotation, scale, and shear (Pang et al., 2023). By using affine transformation, the shape and structure of traditional houses can be represented mathematically through these techniques. This approach makes it easy to see how the shape of a traditional house can be modified and visualized in two-dimensional or three-dimensional space (Chen & Ja'faruddin, 2021).

Along with the times, various software applications are now present to support us in representing an object more accurately and efficiently. Blender is an example of software used for 3D content creation or editing. It is a free and open-source application developed by the Blender Foundation. Blender has features for creating and editing mesh-based 3D models, advanced material and texture specifications, animation systems, physical renderers and a well-integrated Python-based API (Application Programming Interface) (Southall & Biljecki, 2017). In this study, Blender will be used by researchers to model the Atakkae traditional house, thus allowing the application of the affine transformation concept through a matrix transformation that includes scale, rotation, and shear settings on each coordinate axis so that it will produce changes in the appearance of the traditional house from various angles.

This research aims to provide a new perspective on the application of affine transformations in terms of modeling geometric structures in traditional buildings and deepen the understanding of the concept of ethnomathematics in the design of the Atakkae traditional house. By using Blender software, it is hoped that the results of this representation can contribute in terms of documenting and preserving cultural values, as well as providing mathematical insights into the geometric structure of traditional Indonesian buildings.

METHODOLOGY

This research uses a descriptive qualitative approach with the aim of describing the application of affine transformations that focus on geometric structures and examining the ethnomathematical aspects contained in the traditional house building of Atakkae, a traditional house of Wajo Regency, South Sulawesi. This research data was taken, collected, and analyzed based on direct observation and literature review from various trusted and relevant journals or articles. The knowledge that has been reviewed from these literatures is used as theoretical and scientific information to achieve the objectives of the research.

There are several steps of data analysis techniques carried out in this study. First, conducting a literature review in the form of searching, collecting, and reading journals or articles about the Atakkae traditional house, affine transformation, and ethnomathematics. The second step was to make direct observations of the Atakkae traditional house located in Wajo Regency, South Sulawesi. This observation includes observing the house as a whole, observing the shape and structure of the building, and visual documentation. The data obtained from observation was then combined with data from the literature that had been collected. The last step taken is to describe the relationship and application of affine transformation to the structure of the Atakkae traditional house by identifying geometric elements represented through matrix transformation, which includes scale, rotation, and shear. This research uses Blender software to model the visualization of the Atakkae traditional house. As well as describing the ethnomathematics aspects contained in the Atakkae traditional house.

RESULTS AND DISCUSSION

Atakkae Traditional House (Sao Raja La Tenri Bali) and Its Philosophy

Indonesia's natural wealth, cultural diversity and traditions are never-ending to be discussed. One manifestation of this cultural wealth is the traditional houses that spread from Sabang to Merauke. Indonesian traditional houses are not only unique in form and structure, but also contain stories and philosophies of the lives of local people. In South Sulawesi Province, one of the traditional houses that reflects this cultural wealth is the stilt house belonging to the Bugis tribe. The Bugis tribe itself has various groups, one of which is Bugis Wajo.

One of the most famous traditional houses of this group is Sao Raja La Tenri Bali, also known as Atakkae Traditional House. The name comes from the Bugis language, where "Sao Raja" means the king's palace, while "La Tenri Bali" refers to the name of a king who once ruled the Wajo Kingdom, namely Arung Matoa La Tenri Bali. This traditional house is located in Atakkae Village, Tempe Subdistrict, Wajo Regency, about three kilometers to the east of the center of Sengkang City. The uniqueness of Sao Raja La Tenri Bali lies in its enormous size and grandeur. As a typical South Sulawesi stilt house, it has 101 poles, each weighing around two tons, earning it the nickname "the house of 101 poles". The dimensions of the house are also extraordinary: the height reaches 8.10 meters from the ground to the attic, the length is 42.20 meters, the width is 21 meters, and the roof height reaches 15 meters. This far exceeds the typical Bugis stilt house, which generally has 12 to 20 columns (Tokang et al., 2023).

Affine Transformation

An affine transformation is one of the fundamental concepts in mathematics (Xue et al., 2022). It serves several purposes, including adjusting view composition, facilitating the creation of symmetrical objects, providing different perspectives in object observation, and moving one or more objects to another location, particularly in computer animation applications (Choi & Bajić, 2021; Zheng et al., 2021). Basic affine transformations include translation, scale, rotation, and shear (Shabrillah et al., 2024).

- Translation: shifting a set of points by a certain distance along the x and y axis.
- Scale: changing the size of a set of points, either enlarging or shrinking, along the x and y axis.
- Rotation: rotating a set of points around the origin (the center of coordinates).

- Shear: displacing the positions of a set of points proportionally to their x and y coordinates.

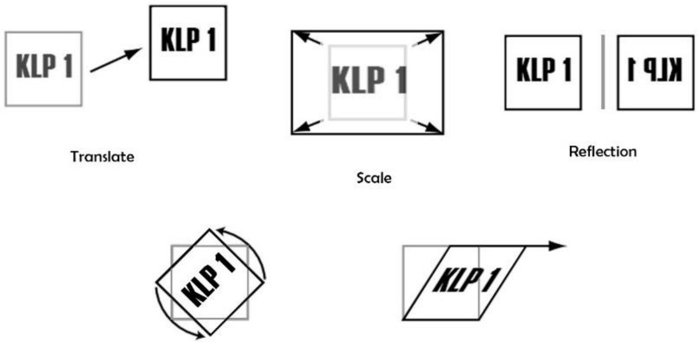

Figure 1. Basic affine transformations and reflections

2D Affine Transformation

A 2D affine transformation is a process used to transform the coordinates of points in a two-dimensional coordinate system into coordinates in another two-dimensional system (Pang et al., 2023). Let $x=(x,y)$, the affine transformation of x on a plane is defined as:

$$x'=ax+by+cdx+ey+f \tag{1}$$

where $x'=ax+by+c$ and $y'=dx+ey+f$.

Affine transformations that include scale, rotation, and shear are linear transformations that can be represented by matrix multiplication applied to a vector representing a point.

$$x'=Mx \tag{2}$$

$$x'y'=ax+bydx+ey=abdexy \tag{3}$$

For the purpose of coordinate transformation, the point $x=(x,y)$ is represented as a 2D vector xy, which is then converted into a homogeneous 3D vector:

$$xy\Rightarrow xy1$$

Linear transformations for scale, rotation, and shear can be expressed in matrix form as follows:

- Scale: $sx00sy$, where sx and sy scale the x- and y-coordinates of a point, respectively.
- Rotation: $\cos\theta\text{-}\sin\theta\sin\theta\cos\theta$, where θ is the counterclockwise rotation angle with respect to the origin (0,0).
- Shear: $1hxhy1$, where hx is the horizontal shear factor and hy is the vertical shear factor.

The 2D matrix form can be extended to a homogeneous 3D form by adding an extra row and column, resulting in the following structure:

- Scale: $sx000sy0001$
- Rotation: $\cos\theta\text{-}\sin\theta 0\sin\theta\cos\theta 0001$
- Shear: $1hx0hy10001$

3D Affine Transformation

Let $x=(x,y,z)$ be represented as a vector xyz, which is then converted into a homogeneous vector as follows:

$$xyz\Rightarrow xyz1$$

The following matrices represent basic affine transformations in 3D, expressed in homogeneous form:

- Scale: sx0000sy0000sz00001, where (sx,sy,sz) are the desired scale factors along the x-, y-, and z-axis, respectively.
- Rotation:
  Rotation about the x-axis: 10000cosθx-sinθx00sinθxcosθx00001
  Rotation about the y-axis: cosθy0sinθy00100-sinθy0cosθy00001
  Rotation about the z-axis: cosθz-sinθz00sinθzcosθz0000100001
- Shear: 1hxyhxz0hyx1hyz0hzxhzy100001, where hxy,hxz,hyx,hyz,hzx, and hzy are the shear factors (constants) along the respective planes.

Affine Transformation of Atakkae Traditional House (Sao Raja La Tenri Bali)

The Atakkae traditional house can be used as a three-dimensional (3D) object to study basic affine transformations, such as scale, rotation, and shear. These affine transformation concepts are applied and explained using the Blender application, making it easier to visualize changes in the shape and position of objects on the plane.

Scale

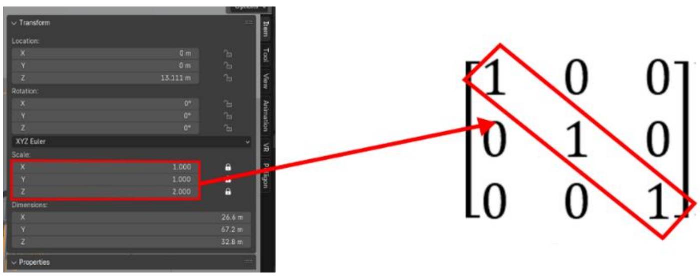

Figure 2. Scale matrix in Blender

The values on the diagonal elements in Figure 2 represent the scale factors for the , and axis. Changes in the scale values in the matrix elements can enlarge, reduce, or reflect objects on a particular axis.

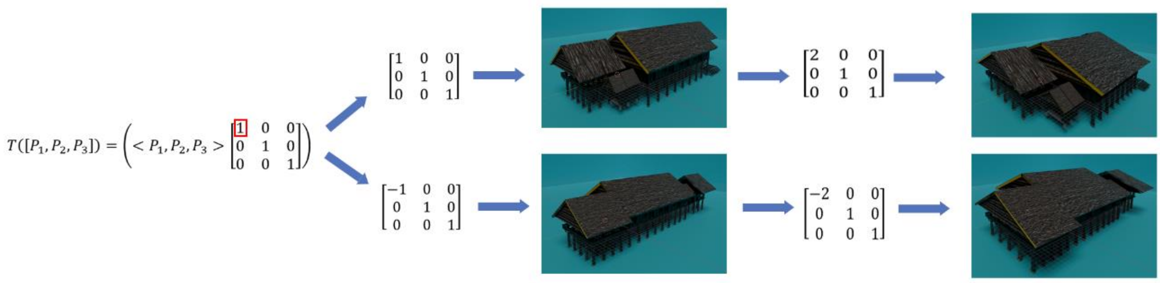

Figure 3. Scale affine transformation

In Figure 3, the scale values on the X axis (sx) is 2, while the scale value on the Y (sy) and Z (sz) This means that the object of the traditional house building is enlarged twice on the X axis, while the Y and Z axis are fixed. This causes the traditional house to appear wider horizontally.

100010001⇒200010001

On the other hand, the matrix -200010001 reflects the custom house object on the axis thus making the custom house appear inverted on the X.

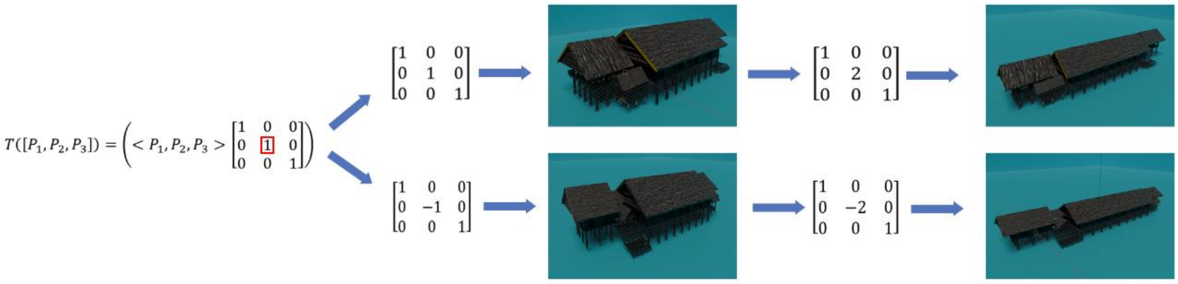

Figure 4. Scale affine transformation

Figure 4 shows a scale matrix with sy elements to resize the object on the Y. The matrix 100020001 matrix enlarges the object on the axis causing the custom house to appear vertically longer, while the matrix 1000-20001 reflects the custom house object on the Y axis so that it appears inverted on that axis.

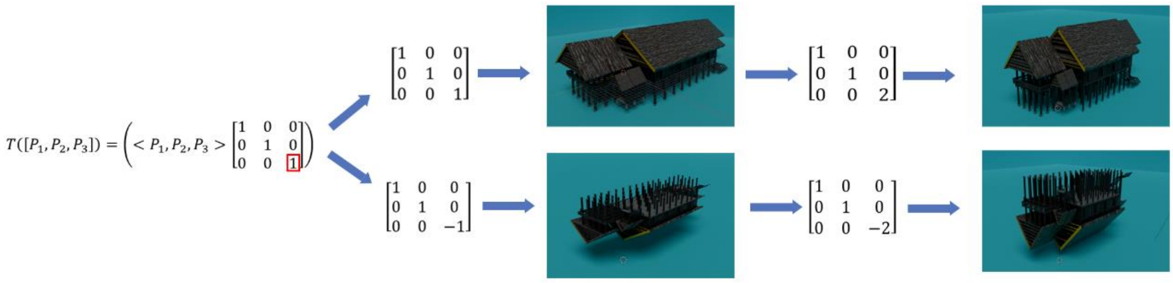

Figure 5. Scale affine transformation

In Figure 5 the scale matrix changes from 100010001 to 100010002. With the value of sz=2, the object of the traditional house building is doubled on the Z axis. This makes the object appear taller or longer vertically. The matrix 10001000-2 makes the object of the traditional house experience double magnification and reversal (mirroring) on the Z axis.

Rotation

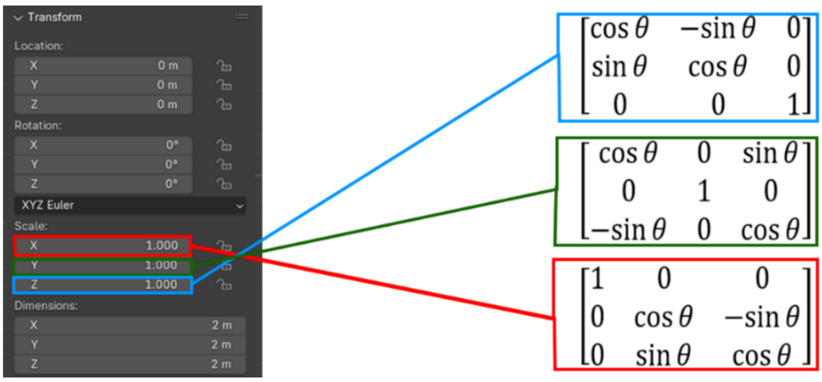

Figure 6. Rotation matrix in Blender

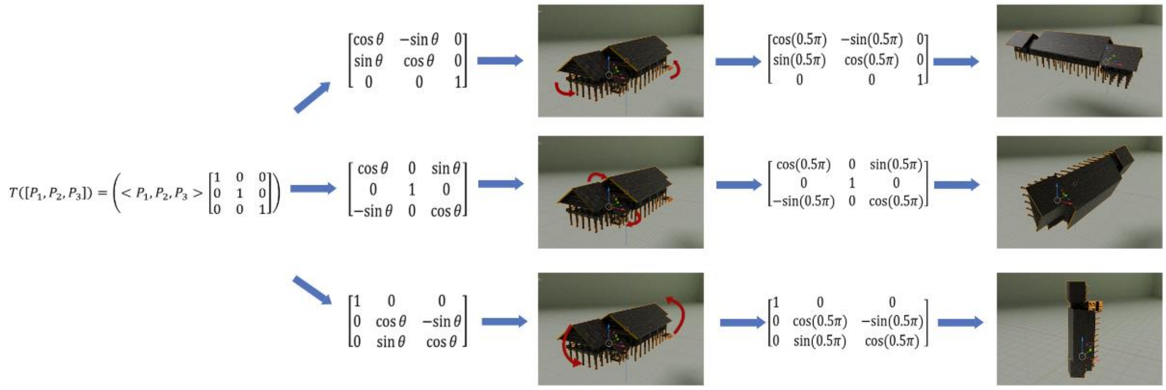

Figure 7. Rotational affine transformation with respect to X,Y,Z axis

Figure 7 shows the rotation transformation process of the Atakkae traditional house with respect to the X-axis, Y-axis, and Z-axis.

- Rotation about the X-axis (see Figure 6 marked in red)
  In this rotation, the object is rotated around the X-axis using the matrix 1000cosθ-sinθ0sinθcosθ. This rotation causes the traditional house object to rotate in the Y-Z plane, while the position in the X-axis remains fixed. This results in a vertical or upright rotation of the object, as shown in Figure 3 below with θ=0.5π.
- Rotation on the Y-axis (see Figure 6 marked in green). The object is rotated around the Y-axis using a rotation matrix cosθ0sinθ010-sinθ0cosθ. This rotation causes the traditional house object to rotate in the X-Z plane, while the position in the Y-axis remains fixed. The result is a rotation that makes the object appear to be tilted to the side, as shown in the center of Figure 3 with θ=0.5π.
- Rotation on the Z-axis (see Figure 6 marked in blue). The object is rotated around the Z-axis using the matrix cosθ-sinθ0sinθcosθ0001. This rotation makes the object rotate in the X-Y plane, while the position in the Z-axis is fixed. Rotation on the Z-axis results in horizontal rotation of the object, as seen in Figure 3 above with θ=0.5π.

Shear

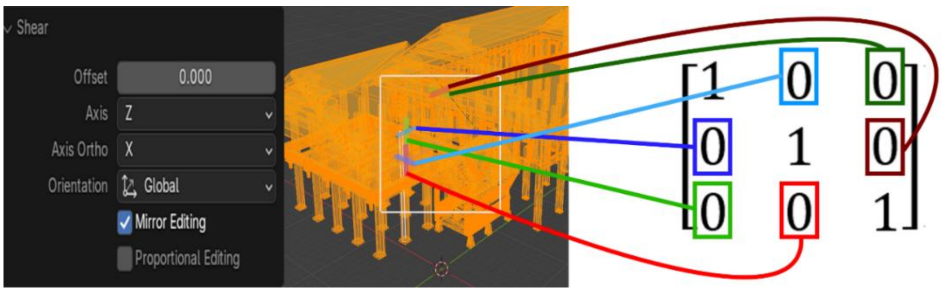

Figure 8. Shear matrix in Blender

The process of using the shear transformation in Blender software is shown in Figure 8. On the left, there is a shear settings view in Blender with several options, such as:

- Offset: to set the level of shear.
- Axis: determines the main axis that will be the reference of the shear (here is the Z-axis).
- Axis Ortho: determines the axis orthogonal to the main axis (here is the X-axis).
- Orientation: sets the orientation of the transformation (set to Global).

- Mirror Editing: enabled so that the shear is symmetrical on both sides of the model.
- Proportional Editing: not enabled, so that the transformation only applies to the selected part.

On the right of the image, there is a representation of the shear matrix used in this transformation. This matrix is the identity matrix with additional elements that can change the coordinates of the object according to the shear value. The matrix shown is:

100010001

Each line color indicates the specific elements in the matrix and how they are used to adjust the direction and degree of shear according to the selected axis.

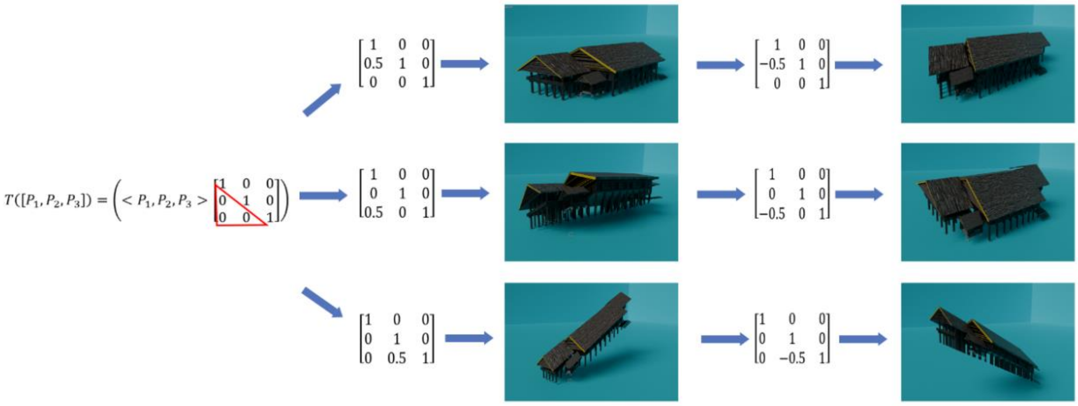

Figure 9. Affine shear transformation

In Figure 9;

The first matrix 1000,510001 changes to 100-0,510001, meaning that a value -0,5 indicates that the axis is shifted proportionally to the axis, but in the opposite direction compared to the previous matrix which had a positive value. The result is that the custom house model appears to be tilted in the opposite direction from the sliding direction produced by the matrix without the negative sign.

The second matrix 1000100,501 changes to 100010-0,501, meaning that a values -0,5 indicate that the axis are shifted proportionally to the axis, but in the opposite direction of the shear with positive values. The result is that the traditional house model looks tilted downward or in the opposite direction of the positive value shear.

The third matrix 10001000,51 changes to 1000100-0,51, meaning that a value -0,5 indicates that the axis is shifted proportionally to the axis, but in the opposite direction compared to the positive shear. As a result, the traditional house model will appear tilted in the opposite direction on the axis to the previous shear.

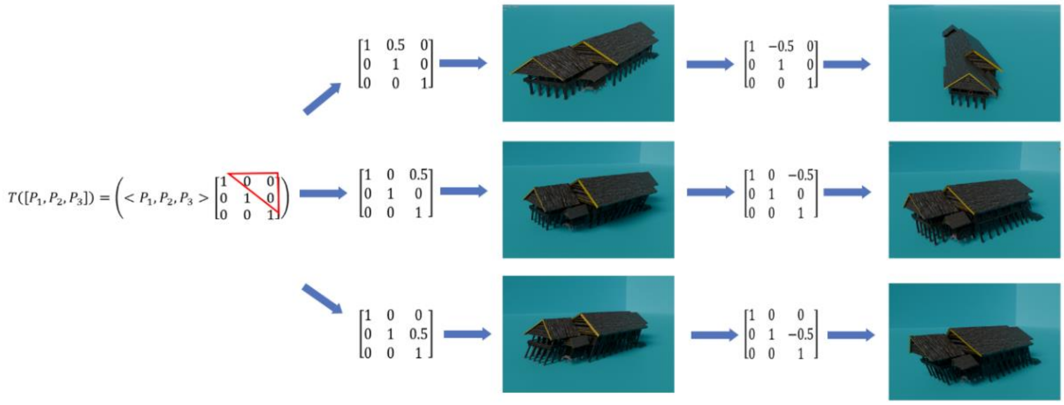

Figure 10. Affine shear transformation

In Figure 10;

The first matrix 10,50010001 changes to 1-0,50010001, meaning that a value of -0,5 indicates that the axis is shifted proportionally to the axis, but in the opposite direction compared to the previous matrix which had a positive value. The result is that the custom house model appears to be tilted in the opposite direction from the sliding direction generated by the matrix without the negative sign.

The second matrix 100,5010001 changes to 10-0,5010001, meaning that a value of -0,5 indicates that the axis will be shifted proportionally with respect to the axis, but in the opposite direction from the shear with a positive value. The result is that the traditional house model looks tilted downward or in the opposite direction of the positive value shear.

The third matrix 100010,5001 changes to 10001-0,5001, meaning that a value of -0,5 indicates that the axis will be shifted proportionally with respect to the axis, but in the opposite direction compared to the positive shift. As a result, the custom house model will appear tilted in the opposite direction on the axis to the previous shear.

CONCLUSION

This study demonstrates that the application of affine transformations, including scale, rotation, and shear, provides a mathematical perspective on the geometric elements of the Atakkae traditional house design (Sao Raja La Tenri Bali). These transformations not only facilitate a better understanding of the geometric structure of the building but also enable more detailed analysis of positional and dimensional changes. Digital technology, such as Blender software, has proven effective in visualizing the three-dimensional (3D) objects of the Atakkae traditional house. Using Blender, affine transformations can be directly applied, simplifying the visualization of changes in the house's shape from various perspectives.

The findings of this study make a significant contribution to understanding ethnomathematics concepts. This research reveals that local cultural elements, such as the Atakkae traditional house, can be linked to modern mathematical concepts, creating a bridge between cultural traditions and scientific knowledge. Overall, the study's findings indicate that integrating affine transformations with a digital approach can serve as an innovative method for studying, documenting, and preserving cultural heritage. This approach not only enhances mathematical understanding but also enriches appreciation for Indonesia's cultural diversity.

For future research, it is recommended to explore the application of affine transformations to other traditional Indonesian buildings to identify unique geometric patterns and local wisdom from different regions. Such studies could broaden insights into the relationship between ethnomathematics and traditional architectural design while analyzing the adaptation of affine transformations for more complex elements using other 3D modeling software. Additional research could also incorporate interdisciplinary aspects, such as the influence of culture and technology in the preservation and development of ethnomathematics-based learning.

BIBLIOGRAPHY

Chen, W-H., & Ja'faruddin, J. (2021). Traditional Houses and Projective Geometry: Building Numbers and Projective Coordinates. *Journal of Applied Mathematics*, *2021*, 1–25. https://doi.org/10.1155/2021/9928900

Choi, H., & Bajić, I. V. (2021). Affine Transformation-Based Deep Frame Prediction. *IEEE Transactions on Image Processing*, *30*, 3321–3334. https://doi.org/10.1109/TIP.2021.3060803

Ja'faruddin, J., & Chen, W-H. (2023). Fostering Ethnomathematics in Projective Geometry: A Hypnoteaching Framework for Effective Distance Learning. *Southeast Asian Mathematics Education Journal*, *13*(2), 85–108. https://doi.org/10.46517/seamej.v13i2.240

Ja'faruddin, J., & Naufal, M. A. (2023). Ethnomathematics: Two-Dimensional Figure Geometry Concept in the Balla Lompoa Traditional House in South Sulawesi. *Mosharafa: Jurnal Pendidikan Matematika*, *12*(3), 667–674. https://doi.org/10.31980/mosharafa.v12i3.834

Laukum, M., Rosmiati, R., Sedia, M. E., Khadijah, K., & Hindi, A. N. A. M. (2024). Eksplorasi Etnomatematika pada Konsep Segitiga dalam Rumah Adat Bugis-Makassar. *Kognitif: Jurnal Riset HOTS Pendidikan Matematika*, *4*(1), 44–56. https://doi.org/10.51574/kognitif.v4i1.1194

Pang, W., Zhu, D., Liu, C., & Wang, L. (2023). The Multi-AUV Time-Varying Formation Reconfiguration Control Based on Rigid-Graph Theory and Affine Transformation. *Ocean Engineering*, *270*, 113521. https://doi.org/10.1016/j.oceaneng.2022.113521

Pratiwi, J. W., & Pujiastuti, H. (2020). Eksplorasi Etnomatematika pada Permainan Tradisional Kelereng. *Jurnal Pendidikan Matematika Raflesia*, *5*(2), 1–12. https://doi.org/10.33369/jpmr.v5i2.11405

Putri, L. I. (2017). Eksplorasi Etnomatematika Kesenian Rebana sebagai Sumber Belajar Matematika pada Jenjang MI. *Jurnal Ilmiah Pendidikan Dasar*, *4*(1), 21–31. http://dx.doi.org/10.30659/pendas.4.1.%25p

Riswati, S., Netriwati, N., & Suherman, S. (2021). Identifikasi Etnomatematika pada Alam Gemisegh sebagai Kekayaan Matematika dan Budaya Lampung. *Jurnal Pendidikan Matematika Raflesia*, *6*(2), 55–67. https://doi.org/10.33369/jpmr.v6i2.15607

Shabrillah, L., Fatahillah, R., Prastyo, R. N., Azqia, S., & Rosyani, P. (2024). Implementasi Teknik Rotasi Gambar Menggunakan Metode Affine Transformation dengan Python dan OpenCV. *AI dan SPK: Jurnal Artificial Intelligent dan Sistem Penunjang Keputusan*, *2*(1), 1–6. https://jurnalmahasiswa.com/index.php/aidanspk/article/view/1334

Sihite, A. C. B., Manik, H., Manao, M. M., Tambunan, H., & Sitepu, S. (2022). Etnomatematika: Eksplorasi Rumah Adat Omo Hada Nias Utara pada Konsep Geometri. *SEPREN: Journal Mathematics Education and Applied*, *4*(2), 46–55. https://doi.org/10.36655/sepren.v4i01.749

Siregar, R. M. R., & Dewi, I. (2022). Peran Matematika dalam Kehidupan Sosial Masyarakat. *Scaffolding: Jurnal Pendidikan Islam Dan Multikulturalisme*, *4*(3), 77–89. https://doi.org/10.37680/scaffolding.v4i3.1888

Southall, R., & Biljecki, F. (2017). The VI-Suite: A Set of Environmental Analysis Tools with Geospatial Data Applications. *Open Geospatial Data, Software and Standards*, *2*, 1–13. https://doi.org/10.1186/s40965-017-0036-1

Sulistyani, A. P., Windasari, V., Rodiyah, I. W., & Muliawati, N. E. (2019). Eksplorasi Etnomatematika Rumah Adat Joglo Tulungagung. *Media Pendidikan Matematika*, *7*(1), 22–28. https://doi.org/10.33394/mpm.v7i1.1537

Susanto, F. P. K., Heryanto, D. R., & Rautac, D. A. U. (2022). Eksplorasi Etnomatematika pada Rumah Adat Joglo Sinom Limas. *PRISMA, Prosiding Seminar Nasional Matematika*, *5*, 483–491. Retrieved from https://journal.unnes.ac.id/sju/prisma/article/view/54568

Tokang, M., Yumame, J., Sriyono, & Ilham. (2023). Seeing the Atakkae Traditional House: Education, Tourism, Economic and Government Policy Perspectives in Its Development. *Journal of Educational Analytics*, *2*(2), 141–156. https://doi.org/10.55927/jeda.v2i2.4062

Xue, X., Zhang, K., Tan, K. C., Feng, L., Wang, J., Chen, G., Zhao, X., Zhang, L., & Yao, J. (2022). Affine Transformation-Enhanced Multifactorial Optimization for Heterogeneous Problems. *IEEE Transactions on Cybernetics*, *52*(7), 6217–6231. https://doi.org/10.1109/TCYB.2020.3036393

Zheng, W., Yu, H., & Lu, Z. (2021). Two-Step Affine Transformation Prediction for Visual Object Tracking. *IEEE Access*, *9*, 36512–36521. https://doi.org/10.1109/ACCESS.2021.3056469