Orizuru Deformation Theory for Unbounded Quadrilaterals

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We fold an orizuru usually from the square paper. It is easy to fold an orizuru from not only any *diamond-shape* but also any *kite-shape*. However, if we choose the intersection of two diagonal lines as the center of orizuru, then we get a non-symmetric orizuru. Husimi found a method to fold a symmetric orizuru from any kite-shape. Justin (1994) extended the Husimi deformation to non-symmetric convex quadrilaterals. He proved that one can fold a head-wing interchangeable orizuru from a convex quadrilateral if and only if the quadrilateral has an inscribed circle. In his method, the intersection of two hyperbolas is chosen as the center of orizuru. One passes A and C with focuses B and D. The other passes B and D with focuses A and C. Such a point exists if an d only if the quadrilateral has an inscribed circle.

On the other hand, Maekawa found a new type of orizuru. Although the Maekawa deformation can be applied to the square, it is outside of Justin's scope. It's because his theory is based on triangulation of the paper and the Maekawa deformation deduces a quadrilateral partition. T. Kawasaki (1996) proposed an orizuru deformation theory based on quadrilateral partition. So his deformation theory is applicable to the Maekawa deformation. Moreover, it can deal with non-convex quadrilaterals. He also proved that one can fold an orizuru from a quadrilateral if and only if it has an inscribed circle.

The aims of this talk are to extend the orizuru deformation theory to unbounded quadrilaterals and to show that we need parabolas and ellipses besides hyperbolas to define the center of the unbounded quadrilateral.

[1] Husimi K. and Husimi M., *Geometry of Origami*, Nippon Hyoronsha (1979). Japanese
[2] Justin J., Mathematical remarks about origami bases, Symmetry: Culture and Science, 5, 153–165 (1994).
[3] Kasahara, K., *Viva Origami*, Sanrio (1983). Japanese.
[4] Kawasaki, T., Extension of systematic construction of flat origami cell decompositions and its application - Deformation theory of bird base, Sasebo National college of technology Working paper No. 32, 29–58 (1996).
[5] T. Kawasaki, ow, Morikita Publishers (1998) Japanese, English translation, *Roses, Origami, and Mathematics*, Japan Publications Trading co., LTD, (2005).