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Folding optimal polygons

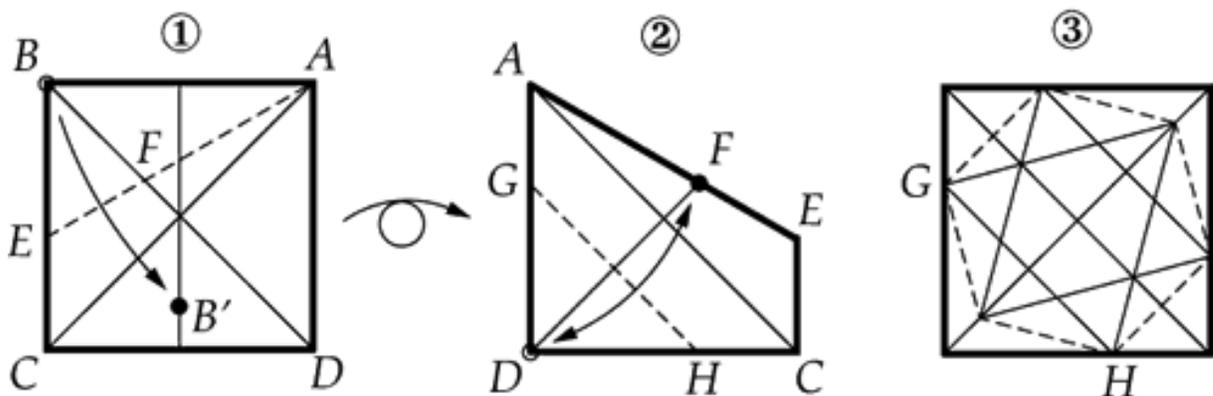
by David Dureisseix



I have looked at various ways of folding the "optimal" pentagon & hexagon (the largest regular hexagon within a square of paper). Additive constraints are a mathematically exact construction, a finite number of operations (no iterative method) and, of course, a folding sequence as simple as possible.

Hexagon

1. The corner B comes in B' on the medium vertical line. This allows us to build the intersection F of the fold AE with the diagonal BD. Reverse the model.
2. Fold D onto F.
3. Resuming the construction to get the optimal hexagon is also easy.

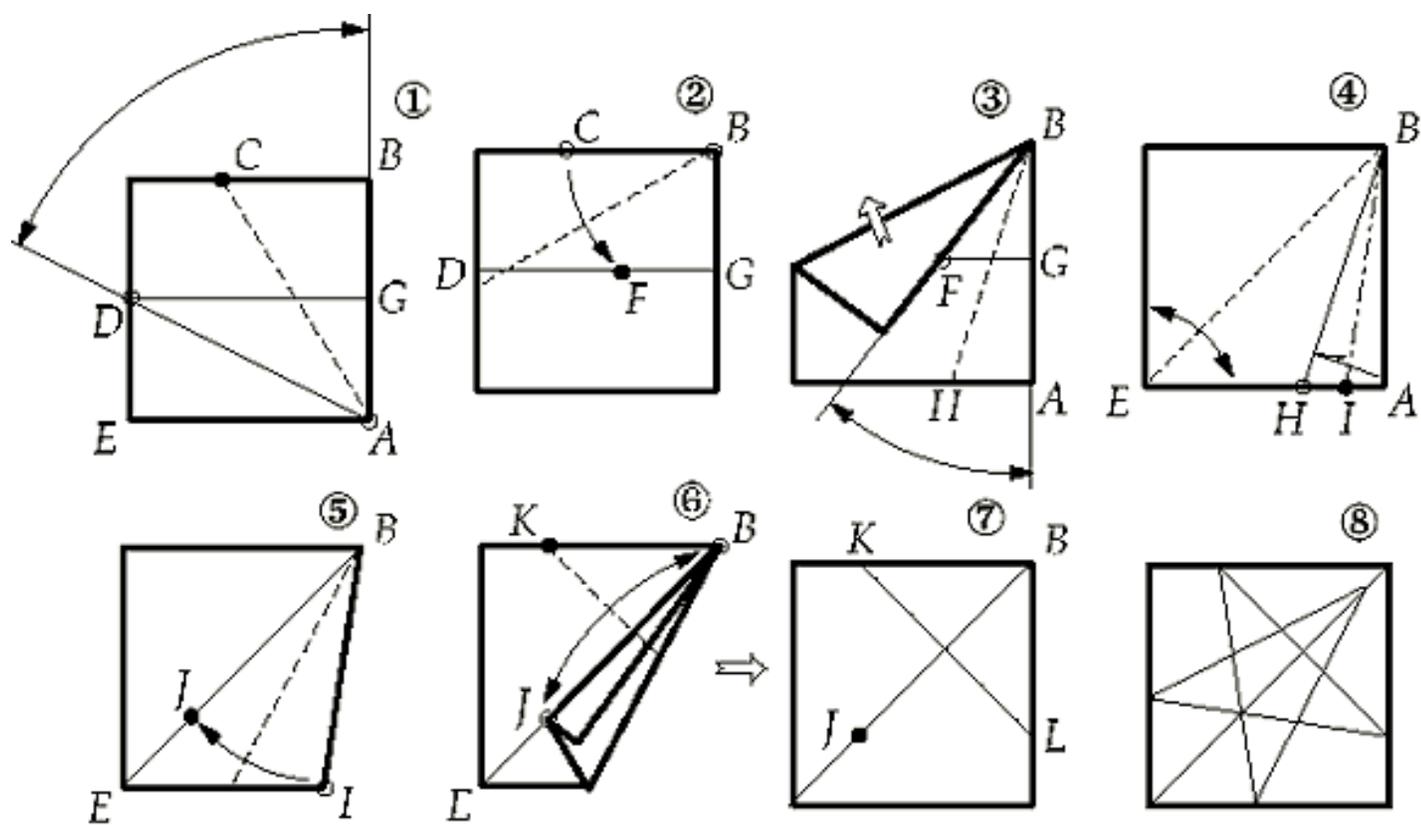


Pentagon

The goal is now to fold a regular pentagon, as large as possible, within a square of paper. In origami geometry, there exists a lot of techniques to fold an approximate pentagon. Much less are concerned with exact pentagon, and only one about optimal pentagon: R. Morassi, The elusive pentagon, in the proceedings of the First International Meeting of Origami Science and Technology, H. Huzita, editor, Ferrara, pp. 27- 37, 1989. The one proposed herein is much simple.

$$\frac{BC}{AB} = \frac{\sqrt{5}-1}{2}$$

1. fold AD onto AB where D is the middle of the edge in order to build C. $\frac{BC}{AB} = \frac{\sqrt{5}-1}{2}$ is the golden ratio.
2. bring C on the horizontal mid-crease.
3. bisect the complementary angle.
4. bisect again and mark the diagonal BE.
5. bisect again. I goes on J.
6. half way: B goes on J. Unfold.
7. & 8 complete the stellated pentagon.



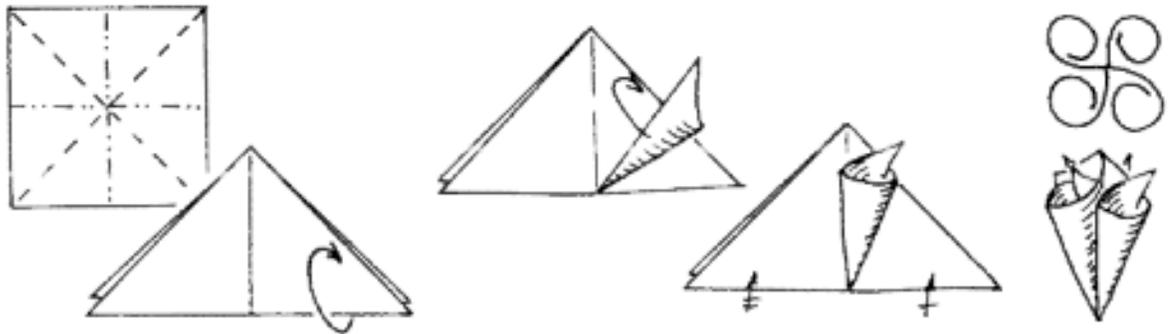
origami
Theory



Curler Units

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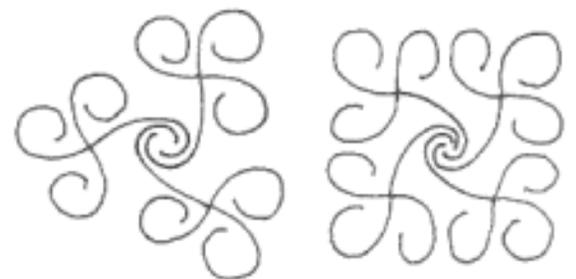
Use small squares (max 7x7 cm) of stiff paper. Ordinary origami paper is too thin, but photocopy paper works very well. Make a waterbomb base and curl each of the flaps into a cone. As shown in the top view, all flaps are curled clockwise (left-handed folders may find it easier to work from a mirror image of these diagrams - sorry!)



The paper should stay curled up as indicated (that's why you need heavier paper) so initially you'll need roll up the flaps a bit tighter than shown in the drawings as the curls will open out slightly when you let go.



To assemble the units, gently ease one curl inside another curl. You can combine 2, 3, 4, 5... curls this way to create many-armed vortexes. You can think of a 3-vortex as a triangle, a 4-vortex is a square and so on. Combining the curls of a number of these units into vortexes you can make several different polyhedra.



The final drawing (below) shows a cuboctahedron. For this, you'll need 12 units. Join 3 units in a 3-vortex. Join the curls along the 3 edges of this "triangle" and add more units to make each of these linked curls into a 4-vortex.

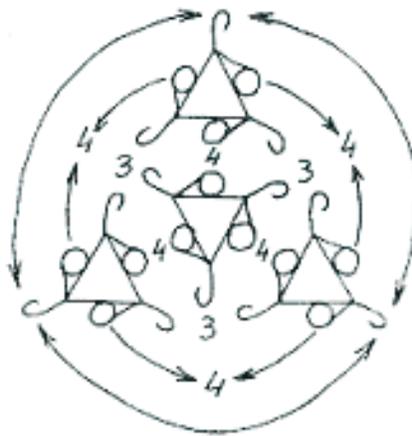


Continue building the cuboctahedron until you run out of units. Take care never to put more than one curl of a unit in the same vortex. If you lose track of the curls, just remember that each square is surrounded by 4 triangles and each triangle is surrounded by 3 squares.

If this explanation doesn't work for you, try the diagrams at the right. First



you join 3 units in a sub-assembly (which we simplify to a "curly triangle") and then join 4 of these sub-assemblies as indicated in the big drawing on the right. The arrows and numbers indicate how many curls are joined at each position.

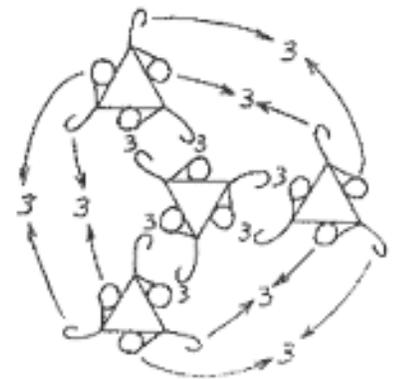


Further experiments : To make an icosidodecahedron (which consists of 3-vortexes and 5-vortexes) you'll need 30 units. Construction is similar to the cuboctahedron but here each pentagon is surrounded by 5 triangles and each triangle is surrounded by 3 pentagons. When you make constructions with this many units, it's a good idea to make the curls a little tighter (and looser if you use less units, though such sparse assemblies are not as attractive and stable. The 6-unit octahedron, for instance, is rather fragile because the curls are overstretched).

You can construct other polyhedra this way (obvious candidates are the (small) rhombicuboctahedron and the (small) rhombicosidodecahedron) but only if there are exactly 4 faces meeting at every corner (vertex) of the polyhedron. This is because the waterbomb base has exactly 4 flaps !

If you really want to make polyhedra with 3 faces meeting at the corners you could put 2 curls of a unit in the same vortex or tuck away the fourth flap inside the waterbomb base or just leave 1 curl unconnected (if there is enough room in the vortex) but none of these solutions are very elegant.

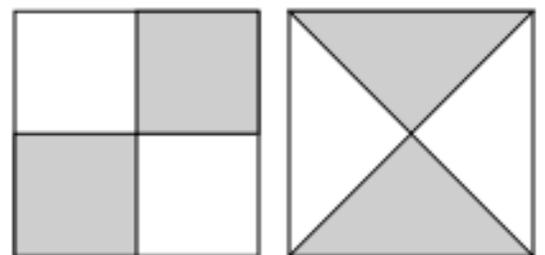
To make the icosahedron (which has 5 faces meeting at each corner) we just leave a hole where the 5th face should go. As it's quite tricky to assemble, here's another diagram to help you. You use the same 4 sub-assemblies as for the cuboctahedron, but put them Figure 1 together in a slightly different way. The resulting figure is strangely irregular : it looks a bit like an icosahedron but not quite. The "holes" are pulled further apart than the "filled" triangular faces so the modular only has tetrahedral symmetry (and is in fact closely related to the snub tetrahedron).



Here you see a strange property of these assemblies : the curls act as tiny rubber bands pulling the units together, so that the structure settles at an equilibrium position where the tension in all the curls is minimal (which is usually, but not always, quite a regular configuration).

For the adventurous : A 4-unit tetrahedron is just possible. 3 curls of each unit are joined in 2-vortexes along the tetrahedron's edges, the fourth is unconnected. Or try the 18-unit deltoidal icositetrahedron. All curls are joined in 3-vortexes and those corners of the icositetrahedron where 3 faces meet are left as holes. That's why we only need 18 units instead of 26. Make a 24-unit snub cube, either leaving the 6 square faces as holes or leaving 8 triangular faces as holes (choose those triangles not sharing any edges with the squares)

I haven't experimented with colours : I prefer working in white as the shadows on the curved surfaces show up better. If you want to have a go you could try folding your waterbomb bases from pre-coloured squares with a light-dark pattern as shown in the figures on the right. The cuboctahedron will then have triangular vortexes in one colour and square vortexes in the other (this works for the icosidodecahedron as well). If you don't like using pre-printed patterns, get duo paper, blintz it and then fold the blintzed triangles to create the colour pattern you want to experiment with.



Herman Van Goubergen

Origami Profiles

by John Smith



1 Defining Origami

Recent attempts to define Origami have prompted me to reconsider the problem as one in which the individual's view of Origami itself constitutes a definition. By showing the individual's view as a graphic profile one can see how such common ground there is amongst folders. This seems a more fruitful approach than trying to supply an authoritative definition.

2 The method

The idea is to provide a diagram which shows towards its centre the 'purest' form of Origami and indicates ways in which this limited pure form can be changed to increase the range of effects or technical opportunities. On this diagram a line can be drawn within which the acceptable variations for an individual will lie.

3 'Pure' Origami

The term 'pure' is not meant as a judgement but simply to express the restriction of material and techniques to the minimum from which variations are most easily shown. In its most limited form only the technique of folding should appear - without this we should have no Origami. Clearly the material used should be capable of being folded and retaining a fold. Since we wish to choose a minimum we should demand that our material is of a single colour only, i.e.. that all effects must be achieved purely by folding. Of all the shapes we can choose the most fundamental and simplest is to be preferred. A circle does not seem to me really acceptable because Origami involves straight line folding. I prefer a square which is the first fully symmetric even-cornered regular figure and in many ways the most elementary of the perfect figures.

Thus I shall use a square of single colour as the centre of my chart - it would not change matters very much to use a circle or triangle but I prefer the simplicity of the square.

4 Changing from the pure form

We can distinguish 8 ways in which the centred method of folding (the 'pure' form) can be varied. These are shown in Diagram 1 and will only be briefly defined here.

- **Shaping.** - the outline of the paper is varied.
- **Slitting.** - cuts are used.
- **Supporting.** - additional materials are used to hold or change the shape of the final model.
- **Multilayers.** - 2 or more sheets of material are folded together; in the final model the separate layers are used to create special effects.
- **Multi Sheets.** - the model consists of 2 or more separate sheets which are each folded and then brought together for the final model.
- **Lengthening.** - the Square is 'stretched' in one direction, that is it becomes a rectangle and so on.
- **Decorating.** - the Square is textured or patterned either before or after the creation of the model.
- **Modelling.** - this applies to 3D models where the material is held in curves by special techniques.

5 The changes and the arts and crafts involved

We can now consider in detail the physical changes involved in each of the 8 ways defined and the art concerned. At some point or other an individual will no longer consider that the art involved is Origami and hence that would be a boundary for his or her profile..

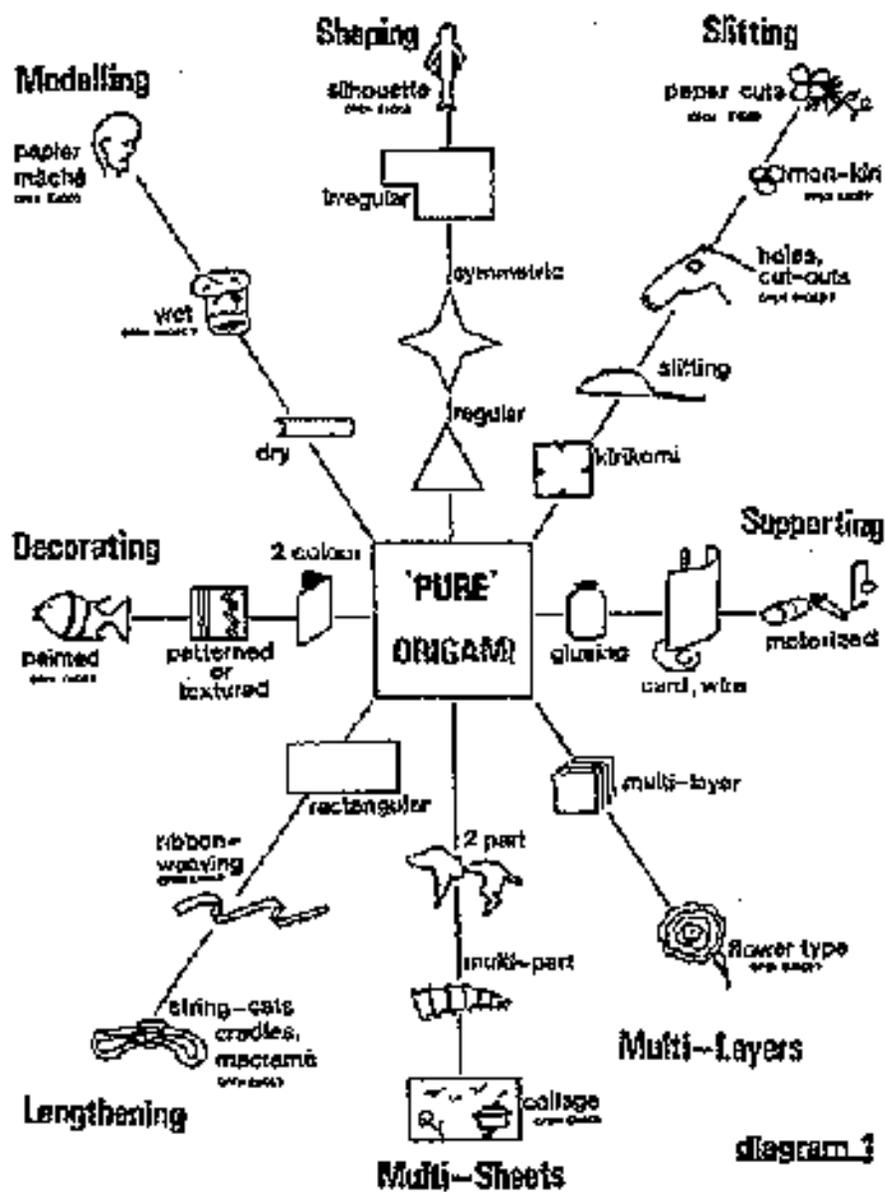


Diagram 1 also shows the results graphically of moving away from the 'purest' form of Origami in each of the eight directions. In some cases I have marked the art as 'open-ended', for example paper-cuts. By this I mean that we no longer have a closed system typical of Origami in which a procedure exists to create a model and can return to the starting point. It is arguable that it is the closed-system through which can some- how break, that is the real characteristic of Origami.

Shaping

Regular figures such as triangles, pentagons are well established for Origami. Kent du Pre (4) has done such work on Symmetric figures such as stars from which flowers can be folded. Irregular figures have appeared occasionally, but the most extreme form occurs in Paper Magic (1) with Rolf Harris's models. Silhouettes (2) have no restrictions in the Origami sense and are of course closely related to paper cutting.

In its simplest form cuts are made prior to folding in a symmetric and planned way which will 'open up' the material available without the need for excessive thickness. The most recent mention of the techniques is by Toshie Takahama who refers to it as Kirikomi and distinguishes it as typical of very early Japanese Origami. (3). Uchiyama is reported (5) as receiving a patent in 1908 for 'KOKO'. style origami which appears to be the same in concept.

Japanese books are full of slitting to achieve ears or a tail or even legs. Perhaps one of the most celebrated examples of theme 'slits to avoid folding' is in Fred Rohm's Circus pony (6) in which 2 cuts are made, one for the ears and the other to give enough points for the legs. Rohm folded his Circus pony without cuts but the technique is then much more complex. Thus we have 2 motives for cutting appearing here; one to create new opportunities and the other to avoid the complexities of a model achieved solely by folding. The cutting out of holes etc. to indicate eyes and so on is sometimes found in Japanese books and we are obviously dealing with a technique which is becoming open-ended.

When we fold in a symmetric way to prepare our paper for cutting the folding has obviously become

secondary (2). Honda has called this kind of paper-craft Mon-Kiri (which means crest-making) (7). The last step in the slitting or cutting is paper-cutting, some of the finest examples are probably from China and clearly here we have an open-ended Art form (8).

Supporting

A way of moving away from the 'pure' central form is that of supporting or adding display mechanics to the models. In its simplest form we may use glue, staples or 'blue tac' to hold a model in the desired pose and position. Or we may use wiring or card.

The most unusual form of 'display mechanics' that I am familiar with is by Toyoaki Kawai (9). In a corner of the Livelihood Industry Pavilion at EXPO' 70, electricity was used to make Origami pigeons flap their wings.

Modelling

It is now usual in animal folds to call for a final modelling particularly when foil has been used and one can be sure of the material remaining in place. A modern example of this is in Pat Crawford's models (10). Neal Elias who probably led the move in the West to 3D insists on any modelling following the folding (11)

The technique of wetting the paper appears to be Japanese in origin was demonstrated by Yoshizawa at a Convention in Birmingham (12). Another method of wet moulding using paste in the preparation is discussed by Alice Gray (13) she was shown it by Yoshizawa during a visit to Japan. The folds tend to be soft and we are approaching sculpture rather than Origami.

In the most extreme combinations of water and paper we are, of course, in the world of papier-mache which is clearly an open-ended art.

Decorating

The simplest step from a single colour is one side coloured and one white or plain. A great deal of modern Origami exploits this colour difference. A delightful example is Joan Homewood's Robin (14). We can use the texture of our material which need not even be foil or paper. Neal Elias collects patterned foil and has shown models in 3 colours which depend upon choosing the right pattern and cutting his material to get the colour exactly where he wants them.

A more restricted form of decoration occurs in Japanese papers which are already printed with a design suitable for a special model. The end of this process is evidently the decoration of the final model and thus into the decorative art proper which is open-ended.

Lengthening

By stretching our square we obtain rectangles then ribbon and finally string. The associated arts are Weaving and Macrame which are open-ended. However with string we can have 'Cats Cradles' which is a closed-systems game with direct analogies to Origami.

Multi-layer

Toshie Takahama has produced some superb examples of this variation of Origami (3). The sheets of paper are folded together but usually opened at the end to show the multi-layers usually with different colours.

In flower folding and possible doll-making the multi-layer technique is exploited for its own sake with little or no folding involved.

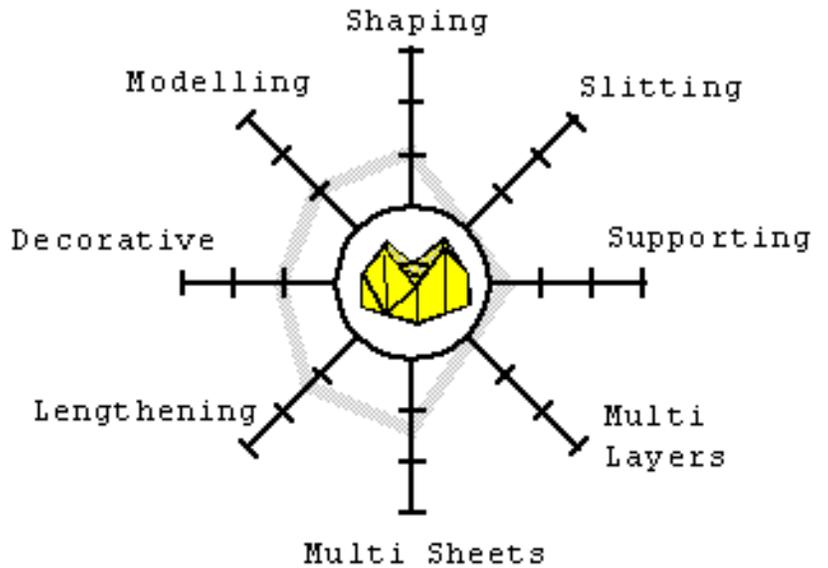
Multi-Part

Isao Honda (15) was probably the first to publish techniques involving 2 separate sheets of paper each folded to represent some part of the animal and then brought together. The idea may well be traditional; if not in the way Honda uses it - see for example the Pagoda in Paper Magic (1). Recently kits have appeared for folding a dragon from a number of squares of different sizes.

Probably the next step in this direction involves in collage using Origami objects. See Takahama (15 16) for some beautiful examples. Clearly we are now in an open-ended art.

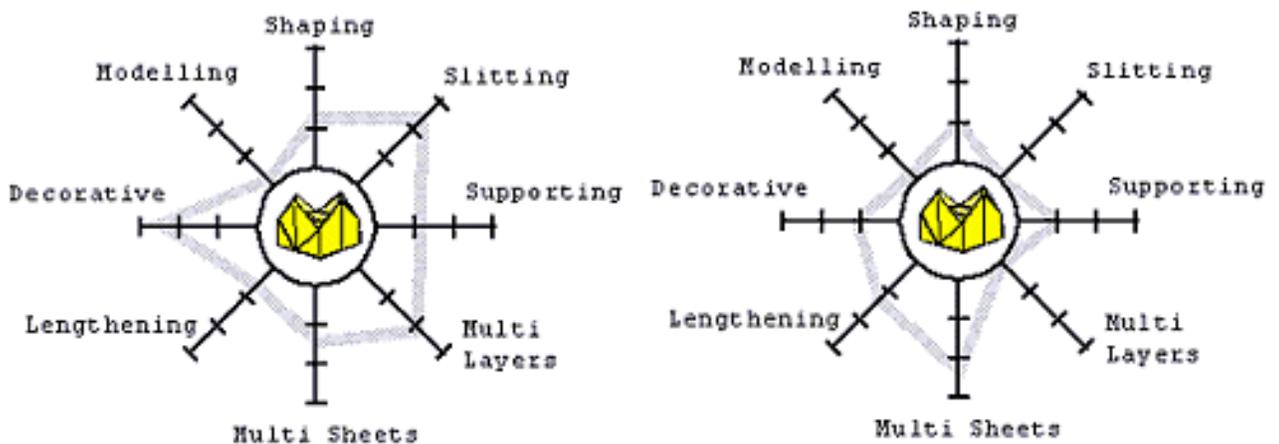
Profile Diagram

The previous diagram is condensed and presented on the form on the right. It is on this that we can draw our profiles. To make the profile as clear as possible a circle has been drawn at the centre and this is the minimum value of the particular characteristic and this defines the 'purest' form of paper-folding. Here is my profile as an illustration and not with any claim that my view of origami is the 'right' one. The line is drawn so that the steps inside the ring are those that I would normally accept as Origami from my point of view.



1. I not consider cutting to be paper-folding so my profile line goes to the centre boundary.
2. I dislike the artificiality of using non-folding means of supporting or presenting a model so again my line follows the centre boundary.
3. I am willing to accept modelling but prefer it to be induced by folds (Curio) and not made by wetting, so the line is a little way from the centre circle.
4. With regard to shapes I am happy with triangles but very rarely consider polynomials with more than 4 sides.
5. Rectangles seem sensible to me but I mainly use A4, I am not very happy with using tape. Using the different colours or patterns on the two sides of my paper is wholly acceptable provided these are not specific to a particular model.

On the left below I give a profile of Origami in its earlier days in Japan. On the right I suggest a diagram which might be the view of a keen modular folder



Now
have
some

fun and on the diagram provided draw your own profile. I look forward to your comments [via e-mail](#).

John. S. Smith.

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The Art of Akira Yoshizawa

an exhibition of his work at Kyoto, Japan

27th April to 7th May, 2000

by David Lister



The Background.

I still find it hard to believe that it happened. On the 30th March, the day before I was about to go away on holiday, I received, entirely unexpectedly, a fax from Mr. Akira Yoshizawa inviting me to go to Kyoto in Japan to attend the opening of his exhibition to celebrate his eighty-eighth birthday. After my initial reaction that in the circumstances this would be quite impossible, I hastened to see my travel agent that afternoon and to my surprise, was able to book a flight from my local airport to Osaka via Amsterdam on the 26th April. There was just time to send a return fax to Mr. Yoshizawa before we set off early the next day to spend two weeks on the Island of Tenerife in the Canary Islands.

I had been aware that Yoshizawa had held his great exhibition to celebrate his life's work last October at the Matsuya Department Store in the Ginza in the centre of Tokyo, but, much as I should have liked to have been there, it had not been possible and I had let the opportunity pass, hoping that possibly I should see the catalogue. The possibility that the exhibition might move to other cities in Japan had not occurred to me. Still less did it occur to me that I might receive an invitation to visit Kyoto from Yoshizawa himself. I count it a very great honour to have been invited.

I first came to know about Yoshizawa and his paperfolding many years ago in 1958, when I read in Robert Harbin's "Paper Magic". Robert Harbin quoted Gershon Legman as saying that Akira Yoshizawa was "far and away the greatest folder in the world and devoted to this delicate and graceful art form to an extent which it is hardly possible to believe". Subsequently I acquired copies of Yoshizawa's books and actually met him when he visited England in October, 1972 to attend a meeting of the British Origami Society. At the time I was Chairman of the Society and got to know Mr. and Mrs. Yoshizawa well. Several other meetings followed including at the Second International Meeting of Scientific Origami at Otsu, to the north of Kyoto in 1994 and another at Munich in Germany in October, 1995. Yoshizawa came to England again in 1983 and 1997. Another time I met him was when he came to Paris Origami in March 1998, where his work was shown in that great exhibition alongside that of many others of the leading folders of the whole world. Each meeting gave me an opportunity to see a small display of his work and also to interview him in my effort to obtain information about his life-story and how he came to be a paperfolder. I was eventually able to write two articles about Yoshizawa and how he developed his paperfolding skills for "British Origami" in 1998 and 1999.

It is true to say that Yoshizawa has distanced himself from other Japanese paperfolders. He has strong views about the nature of folding and in particular

holds that paperfolding should be something more than merely a geometrical and technical accomplishment. For him, paperfolding should represent the animal or bird as a living creature as closely as possible. Over many years he has made repeated visits all over the world sponsored by the Japan Foundation to encourage the study of paperfolding among children and adults alike. He has held frequent exhibitions in Japan and has written many books about folding. His most recent visit abroad was to Oman in March of this year, a remarkable venture for a man of eighty-eight years.

I have often likened him to the guitarist, Andres Segovia, who was similarly self-taught and who transformed the art of the classical guitar out of all recognition both by revolutionising its technique and by extending its repertoire. So Yoshizawa transformed the art of origami from a somewhat stilted paper craft which used extensive cutting to what is an art form in every sense. His first achievement was to break out of the limitations of square paper by developing the possibilities of the bird base. For a time he obtained the necessary "points" to depict an animal with four legs, a head and a tail by using two squares of paper. At first his first models were flat, but they soon became three dimensional. Whereas his early models often had split backs, he quickly discovered how to fold his animals with rounded, closed backs. He originated the technique of wet folding, which enabled him to mould his models, so that his folding became a kind of sculpture. He also learnt to use the more advanced bases that we know in the West as "blintzed" bases. These provided him with an adequate number of "points" and freed him from having to use two squares of paper for his animals. While Yoshizawa's techniques have remained relatively simple and he has eschewed what have been called technical or complex folding techniques, his art has nevertheless developed in technique over the years. We have seen, too, how, apart from his technique, his artistic and creative skills have developed and matured.

Yoshizawa's first introduction to the Japanese public was in the Japanese picture magazine *Asahi Graf* for January 1952, in which he presented a series of figures of the Japanese Zodiac. He had previously held a small display of his work at the Utsunomiya Education Hall in 1950, in connection with a teachers' conference but his first major exhibition was in the Ginza in 1955, sponsored by Tokyo Electric Power. Meanwhile, in 1953, by an unexpected stroke of good fortune, he was discovered for the West by Gershon Legman, an American who was just about to leave the United States to go to live in France. Gershon Legman was able to arrange for an exhibition of Yoshizawa's models at the Stedelijk Museum in Amsterdam in the autumn of 1955. Yoshizawa sent to him the models that had been displayed at his exhibition in the Ginza. In 1956, Robert Harbin's book, "Paper Magic", which quoted a letter from Gershon Legman, spread the news of Yoshizawa's remarkable paperfolding throughout the English-speaking world. At that time an interest in paperfolding was newly emerging in the West and enthusiasts quickly learned about Yoshizawa and his new way of folding. They included Lillian Oppenheimer of New York, the founder of the Origami Center. She made Yoshizawa a vice-president of the Center and in April 1959 she travelled to Japan to visit him.

In May, 1959 the Cooper Union Museum of New York put on an exhibition of paperfolding with the title "Plane Geometry and Fancy Figures" and through the agency of Mrs. Oppenheimer the work of Yoshizawa was included. Gershon Legman sent Yoshizawa's creations from the exhibition at the Stedelijk Museum and Yoshizawa sent more models direct. So, by good fortune, almost from the beginning Yoshizawa's work has been known in the West as well as in Japan. Since then he has held many more exhibitions of his work in Japan and the rest of the world. Now we are forty years on and to celebrate his eighty-eighth birthday, which, because of the symbolic meaning of the characters for 88, is a specially important landmark in Japan he has celebrated his lifetime's achievement by holding the greatest exhibition of them all, first in Tokyo and then in other Japanese cities, including Kyoto.

Perhaps it is appropriate here to pay tribute to the important contribution that Mrs. Kiyo Yoshizawa has made to her husband's work. They married in 1956, just at the time when his work was beginning to be recognised. Since then she has accompanied him on many tours throughout the world and has helped him in so many ways, by acting as his manager, by helping to set out his exhibitions, by teaching and making speeches on his behalf and, as I have good reason to know, by welcoming his guests. She has removed much of the tedious burden of organisation from him Mr. Yoshizawa has been most fortunate in having beside him such a devoted partner.

My Visit to Kyoto.

After a twelve-hour over-night flight from Amsterdam I arrived at Kansai Airport, constructed on an artificial island in the Bay of Osaka at 8.30 am on Thursday, 27th April. Against my expectation, I was met by Mr. Yoshizawa's representative and we took the express train to Kyoto where we were met and driven by car to the Sun Hotel in the centre of Kyoto, where a room had been booked for me. For all its historical reputation and the many temples and shrines scattered throughout the city, Kyoto is very much a modern city, thronged with crowds of people and with streets of taxis, cars and buses seemingly in a perpetual gridlock. That afternoon, I met Mrs. Jean Baden-Gillette, the President of Origami USA who was also a guest of Mr. Yoshizawa and we were taken the short distance to the Takashimaya department store at the busy cross-roads in the centre of Kyoto where the exhibition was being held. Takashimaya at Kyoto is one of the great department stores of the world, very extensive, spacious and very elegant. We took the lift to the seventh floor and to the entrance to the exhibition. I was asked to sign the visitors' book, the first entry not in Japanese, and then I had my first sight of the exhibition, being first confronted by two large flying dragons and a large and impressive model of Godzilla. I began looking round, but before long a lady came up to me, asked me my name and I was taken into a private room where Mr. and Mrs. Yoshizawa were waiting for me and warmly greeted me. I was introduced to other people, including Mr. Katsuji Tachikawa, the Cultural Projects Officer of the Asahi Shimbun newspaper of Tokyo, who were the sponsors of the exhibition and the manager of exhibitions for Takashimaya, who explained that the promotion of artistic exhibitions in department stores was a tradition in

Japan. They had previously held an exhibition of the Impressionist paintings from the Courtauld Collection of London and he generously presented me with a copy of the sumptuous catalogue.

As we talked, we were joined by Giovanni Maltagliati, the secretary of Centro Diffusione Origami, the Italian origami society and his wife, Gianna. We presented our gifts and then went out to see the exhibition. I didn't expect to be able to take photographs, but I thought it worth asking and was pleasantly surprised to be given an armband which made me an official photographer, and which would protect me from interference by the several smartly uniformed security guards. Mr. Yoshizawa was full of life and we took the usual group photographs, exchanging cameras so that everyone would have a record of the occasion.

Then it was time for the celebration dinner held downstairs in the store's luxurious restaurant. Far from being Japanese, the meal was of French cuisine with wines, and elegantly served. I and the other overseas guests were seated with Mr. and Mrs Yoshizawa, and with two Japanese ladies who acted as very capable interpreters. The other tables were occupied by about twenty members of Mr. Yoshizawa's International Paperfolding Society. Before the meal, Mrs. Yoshizawa gave a short speech of welcome and I, followed by Jean Baden-Gillette and Giovanni Maltagliati replied and said how honoured and happy we were to be there. Mr. Yoshizawa presented all the guests with a copy of the catalogue of the exhibition which he autographed for us. I was seated opposite Mrs. Hiroko Ichiyama who had been a member of the staff of Reader's Digest at the time of the publication of the article about Yoshizawa in 1970 and we were able to discuss how Leland Stowe came to write it and how a longer preliminary version the article came to be printed in the Beacon Magazine of Hawaii.

Our entertainment was far from over with the completion of the meal. The next morning, Friday, we were taken by taxi to the Kensoin Buddhist Temple, hidden away in the narrow streets of an obscure part of Kyoto. The overseas guests were joined by a group of members of Yoshizawa's society. Here, the priest in charge was the Revd. Msahiro Inui, a friend of Mr. Yoshizawa and a cheerful friendly man. He greeted us in his dark blue robes as a Buddhist priest and after we had removed our shoes he welcomed us into the worship room of the temple. It was an impressive and sacred place with its ornate altar illuminated on either side by cascades of white "fairy" lights on either side and with a magnificent gilt chandelier suspended above. Mr. Yoshizawa knelt devoutly before the altar and those who wished to do so were invited to burn incense. We were then taken to another room at the back of the temple, where we were seated in a square on cushions on the floor and Mr. Inui gave us an account of the temple. In deference to his age, Mr. Yoshizawa was permitted to sit on a chair. There followed a Tea Ceremony presented by a young lady in a kimono. She was a teacher and had learnt the art from her mother. Several other ladies who were associated with the life of the temple helped by carrying bowls of tea to each of us. Later, we were then shown round the temple, which was very different from the large temples we were subsequently to visit. These were largely public monuments, but this was an active working temple, used

for regular worship and study and it had much the same atmosphere as a busy working church in the West. There were two main buildings, one for worship and formal meetings and one for living, with bedrooms, living rooms and kitchens. They were of recent construction and as we were shown round, the bosses at the ends of the main roof timbers were pointed out to us. They took the form of fierce faces intended to frighten away evil spirits. We were told that these were reproductions of a paper mask and that they had been specially created by Yoshizawa. We later saw the paper original of this mask.

We were taken back to the meeting room for a "luncheon box " meal, as always, tasty and fascinating and, of course, according to Buddhist tenets, vegetarian. Unaccustomed to sitting back on my heels, I somehow managed to fold up my western legs into a reasonably comfortable position which I was just able to maintain. During the meal Mr. Inui presented each of us with a fine coloured picture book of the temple, showing its construction, its dedication and its activities.

Afterwards we were taken to other parts of the complex, including a large library in the basement and a "mausoleum" room, lined with stepped shelves where tokens and mementoes of deceased persons could be kept and where they could be remembered. On the wall at the end of the room was an origami figure of the goddess of mercy that Mr. Yoshizawa had folded for the temple. Mr. Yoshizawa was clearly very devoutly attached to this temple in Kyoto, even though he lives many miles away in the Tokyo area. As we passed through the burial ground which surrounded the temple, we noticed a plot marked as reserved for him.

After lunch, Mr. Inui took us on a walking tour of the neighbourhood, passing several small temples and shrines and one larger shrine, with the small garden bright with spring flowers and with an ancient Camellia tree about a hundred years old. Temples are Buddhist, shrines are Shinto. Buddhism and Shinto have different historical origins, but they co-exist and most Japanese people adhere to both religions. We came to a stream which it was pointed out to us was once used for making paper. Further on we passed a little shop where I noticed some formally folded "noshi" wrappers on sale. We walked a long way and I couldn't help admiring the way Yoshizawa staunchly kept up with the tour, supported by Mrs. Yoshizawa, who held his hand. Eventually we crossed a wide road and came to the entrance to a very large shrine set in a park. Two large traditional stone komainu or lion-dogs lions guarded each side of the entrance to repel evil. Here we parted company with Mr. and Mrs. Yoshizawa, who returned to their hotel by taxi.

This was the Kitano Tenmangu Shrine. It was a big complex of buildings. We walked up a wide path lined with statues, stone lanterns and small shrines and under two gigantic torii, the typical Japanese square gates having a double lintels cross the top. The torii mark the entrance to the sacred enclosure. We entered the shrine proper through the roofed main entrance and we found a cluster of buildings both large and small. What especially interested me were the sacred shimenawa ropes which hung over the entrances to every shrine, big or small. These mark the boundary between the sacred and the profane.

The shimenawa ropes had tied into them bundles of rice straw and o-shide, the white papers cut and folded into zigzags that are another indication of the sacredness of the place. If rocks and trees are considered sacred, they will also have their own shimenawa with rice straw and o-shide tied round them. Within the shrines we could often see a go-hei, which is a double o-shide attached to the top of a wand. I understand that the go-hei signifies the presence of the god. One of the buildings was a museum, full of fascinating exhibits, to enter which we had, as usual, to remove our shoes.

The next day, Saturday we were taken on a coach trip round Kyoto, visiting Higasahi Honganji, another large temple complex with two worship halls, one of them of truly enormous dimensions. We also visited the Nijo Castle which is where the Shogun stayed when he visited Kyoto. I was fascinated by the corridors of the castle, the wooden floors of which were deliberately made to squeak to warn of the presence of intruders. They were delightfully named the "nightingale" floors and that is how they sounded as we walked along them.

We then went on to Kinkaku-Ji, the famous Golden Pavilion, which is overlaid with gold leaf and shimmers across the lake in which it stands. It is set in an exquisite garden, surrounded by shrines and subsidiary temples. From there we were taken to a craft centre. Here we had lunch and had an opportunity of touring the building massed with examples of Japanese workmanship. I was most impressed by some "used" kimonos, which were magnificent in their richness, colour and workmanship, but I limited my purchases to a small "Moroccan" twisted purse and some toothpicks dressed up as paper dolls.

On Sunday we were taken on a spectacular trip through a deep and narrow wooded gorge, along the bottom of which ran the fast-flowing River Hazu. We travelled upstream by an antique "toast-rack" railway, going across bridges and through several tunnels and able to look down on the river below. Our return was even more spectacular and was in boats resembling sampans, each one steered and rowed by three hard-working men. It was an exciting journey down the cascading river, shooting the many rapids. Fortunately the boats were stable and none of us got wet. At one point, where there was a small station on the railway on which we had travelled, there were rows of streamers in the form of carps strung across the river. They were in anticipation of the coming Boys' Day which would be celebrated on 5th May. Throughout Kyoto we saw flagpoles decorated with strings of carps, regarded as the most valiant of fish. Downstream, a motor boat selling food drew up to us and we A motor boat selling food drew up to us and we travelled linked to it for a few minutes downstream while some people bought snacks and our boatmen took a well-earned rest. The river widened and our boat trip came to an end. The Harashiyama area we landed was a holiday area, busy with cafes and souvenir shops. A feature of the area was the many smart modern rickshaws with pneumatic tyres pulled by energetic young men and available for hire. We visited a restaurant to enjoy an elegant lunch under the weeping cherry trees in a pretty garden overlooking the river. During the afternoon, we visited Tenryu-ji another temple with a lake set in a remarkably serene and beautiful garden ablaze with spring blossom and then walked through a forest

of bamboos to see another small complex of shrines, before finding a place for coffee and catching the bus back to the centre of Kyoto

Our formal visit came to an end on the Monday, when we again visited the exhibition at Takashimaya and Mr. and Mrs. Yoshizawa entertained their overseas guests to a farewell tea-party with some of the people who had helped us in our visit. The Revd. Masahiro Inui was also invited. At first we didn't recognise him because he had discarded his formal robes for civilian dress with a colourful woollen sweater. It was another happy occasion at which we ate tea and cakes, chatted with our new-found Japanese friends and took many more photographs. Eventually it was time to go and we reluctantly took leave of Mr. and Mrs Yoshizawa, deeply grateful to them for providing us with such a unique and rewarding experience.

A Tour of the Exhibition.

The exhibition of Yoshizawa's paperfolding was set out in the exhibition hall on the seventh floor of the Takashimaya department store. By any standards, it was a large display hall, perhaps over eighty feet by thirty. Part of the exhibition was displayed on tables protected by transparent plastic shields rising about eighteen inches above the surface of the display table so that one could look over them and see the models directly. Other parts of the exhibition were displayed in fully glassed wall cases lining some of the walls and there were more tall display cases along the centre of the hall.

After passing the two large flying dragons at the entrance, one passed through a fairly narrow aisle and into the main part of the hall. At the far end of the hall a large display case containing a very impressive panorama of the seasons dominated the exhibition. This was a landscape filled with origami figures which started with spring on the left and shaded through summer and autumn to the snow-covered landscape of winter on the right. The panorama presented a wide diversity of scenes from Japanese country life in a landscape filled with birds, animals and country people and with cranes flying above.

Turning round the end of the hall, between the panorama and the cases along the middle and returning down the hall, one passed further large wall-cases before coming to another narrower aisle where there were displayed the models submitted by chosen overseas folders and also photographs of significant events in Mr. Yoshizawa's life. At the end one was led through half-curtains into the sales room where the staff of Takashimaya were doing a brisk trade in everything directly or remotely connected with origami, including books, videos, photographs, origami paper, paper dolls and formal "noshi" envelopes. The mixture of traditional crafts and modern technology is characteristic of the Japan of today.

By any measure, it was a very impressive exhibition with perhaps 2000 or more origami models, all of them folded by Mr. Yoshizawa. There were two exceptions to this: the small display of models by the overseas folders who had been invited to the exhibition when it took place in Tokyo, and an Antarctic

scene in which penguins folded by members of the public during a lesson in origami had been added to Yoshizawa's more advanced models.

Any visitor unacquainted with modern origami would be astonished by the sheer magnitude and quality of Yoshizawa's folding. I managed to visit the exhibition on several occasions and took notes of what particularly impressed me. It had been well-publicised throughout Kyoto and I even saw an advertisement in a train. On each occasion I attended there were many visitors thronging the hall and Yoshizawa was usually to be seen chatting to visitors young and old and explaining his work. Undoubtedly it was a very successful exhibition and I felt sad that it seemed unlikely that the exhibition would be seen in the West. Unfortunately Origami is not an art form that is familiar to the organisers of exhibitions in the West and without the resources of the professional art world, it is difficult for amateurs to put on major exhibitions in large western cities.

The models displayed were mostly of Mr. Yoshizawa's mature period, rounded 3D models with closed backs. Many were wet-folded, showing the plastic moulding that this makes possible. Every kind of animal and bird was represented and I can do no more than mention a few that caught my eye. Near the entrance was a family of lions. The male lion was a proud creature, though in a stylised heraldic way, resembling the lion "supporting" the coat of arms at the head of the London Times newspaper. The lioness and her two cubs were more naturalistic, a playfully relaxed family. Near them was an impressive tiger impressively folded from subtly striped paper.

There was a whole group of gorillas and monkeys. They have been a favourite subject of Yoshizawa for many years and he has published several diagrams for them in his books. However, the published diagrams do not contain the refinements that make it possible for Yoshizawa to breathe life into his own models. There were several diverse variants of the gorillas with impressively fierce facial features. I liked, too, a group of hippopotamuses which successfully caught the enormous bulk of the animals. I was amused, too, by the heads of hippos shown as just projecting from the water, which is, in fact, the way they are usually seen.

Among the birds, I particularly liked a pair of parrots. They were not just the ordinary parrots that anyone else might fold, but lively, arguing parrots engaged in a squawking quarrel. I can think of no other paperfolder who could depict them in this way. The same case was dominated by Yoshizawa's famous peacocks, one with a displayed tail of pleated paper and another sitting on a branch, with a cascading tail. I liked too, the models of the black and white Japanese Cranes, their heads crowned with scarlet. These are the almost mythical birds which have been rescued from near extinction and which gave rise to all the Japanese legends and symbolism of cranes. They were justifiably shown on one of the posters of the exhibition.

Some of the groups of models, like those of sheep showed variants which differed greatly in complexity from very simple, almost abstract designs to complex wet-folded models that were more realistic such as a splendid ram

with massive coiled horns. A whole collection of dogs, was folded so accurately that their breeds could readily be distinguished.

I particularly liked two ferocious bulls about to charge each other and, in contrast, a single hare sprawled out contentedly. One case contained insects, exquisite jewels not very far removed from those of some of the Western folders like Robert Lang and Alfredo Giunta who have specialised in this miniature and tricky field.

By no means all of the models were of animals and birds. Yoshizawa began his professional career with his series of Zodiac figures for Asahi Graf in 1952, and he has not neglected this subject since then. One case contained no less than three sets of Zodiac figures, each one quite different from the others. One composition of which I have previously seen a photograph, I found very impressive. This was of Romulus and Remus being suckled by the wolf, a re-creation in paper of the famous statue in Rome.

Folding of inanimate objects is not what one associates with Yoshizawa. Yet he has always folded them and very well, too. The Panorama of the Seasons contained foldings of many man-made objects, which helped to make up the picture. Another frequent feature was the framed origami pictures similar to those which Yoshizawa sent to Florence many years ago for display in connection with the Pinocchio origami competition. There were pictures of scenes from Japanese folk tales and a charming composition of a group of small birds sitting in a row along a branch. Each bird was an individual with a personality of its own. Two sea horses set behind glass gave the appearance of being under water. Inanimate objects I noticed included a cottage, a ceremonial portable shrine, sheaves of rice set out on a frame to dry and a tiny set of carpenter's tools. Spinning tops, too, are inanimate objects and they seem to fascinate Yoshizawa. There is a whole collection of very diverse forms.

Another kind of folding that one does not readily associate with Yoshizawa is abstract folding. Yet here was a group of several abstract figures reminiscent of what John Smith has called "curio folding" or "curve induced origami." Another unusual concept for Yoshizawa was the folding of a series of paper dolls on a stepped dais for the Girls' Festival on 3rd March. The dolls were folded the traditional style and apparently used the cutting customary in this style of folding. However, styles of paperfolding that were definitely foreign to Yoshizawa's repertoire and absent from the exhibition were modular folding and geometrical folding for the sake of geometrical folding.

A more familiar category of Yoshizawa's work is that of folding masks. He has been folding convincing self-portraits ever since I have known of his work and the exhibition contained yet another excellent self-portrait. There was also a fearful mask of a devil which contrasted sharply with a serene and beautiful mask of a Buddha. But the mask which appealed to me most and, indeed, which I thought was the finest model in the whole exhibition was a strange mask of a pathetic face, possibly based on a Noh mask. The folding used Yoshizawa's traditional techniques, but at the same time, echoed of the masks

of Eric Joisel. I found it mysterious and haunting, a great contrast from Yoshizawa's models of animals and the vision of it has continued to haunt my memory.

The final section of the exhibition contained a number of photographs of events from different periods in Yoshizawa's life. Most fascinating was a school photograph taken in 1925 when he was aged 14. He had recently left home to Tokyo to attend high school in Tokyo. Unfortunately he was unable to afford to stay at the school for more than one year and he subsequently continued his education by attending evening classes. Nearby, there was a collection of books and papers of the greatest interest. They included a copy of Yoshizawa's first and least-known book, *Atarashii Origami Geijutsu* (The Art of Origami) dating from 1954 and a collection of photographs and records from Yoshizawa's exhibition at the Espace Pierre Cardin in Paris in 1984. Another fold towards the final part of the exhibition that I particularly noticed was the figure of the Goddess of Mercies, a replica of the one that we saw in what I have termed the mausoleum room of the Kensoin Temple during our visit.

The exhibition concluded with the small displays from the five Western folders who had been invited to attend the exhibition when it opened in October in Tokyo and to submit just a few models. They were all folders whom Yoshizawa felt to have helped to make known his folding throughout the world. They were David Brill, the present chairman of the British Origami Society, Eric Joisel who played such an important part in organising the Paris Origami exhibition, Jonathan Baxter of the South Eastern Origami Festival in the United States, Michael LaFosse, also of the United States and Carlos Pomaron of Zaragossa in Spain. The portrait of each of them was shown, together with notes about them in Japanese. Much as I sincerely admire their work which is displayed, my own candid feeling was that the space allowed to these folders was too restricted and that the models shown by them were not sufficient to illustrate their undoubted skills as folders. But this was Yoshizawa's exhibition and anything more might have detracted from the special character of the exhibition.

So we passed beneath the curtain and back into the commercial world of the Takashimya store.

The Yoshizawa Exhibition: An Assessment.

I came away from the Yoshizawa exhibition with a new perspective of Yoshizawa's skills as a paperfolder and with a deeper admiration for his unique achievement. It is not often realised today just how great was the revolution that he wrought in the art of paperfolding or just how much the transformation of paperfolding from the middle of the 20th Century was due to him. He was self-taught. He devised his own geometrical and folding techniques and single-handedly transformed Japanese origami from a somewhat stilted, formal pastime into what is truly an art form. Other folders were quick to build on the foundations that he laid, particularly by extending the geometrical complexity of

folding, even to the extent of using computers to assist in the creation of appropriate bases. Other folders have diverged from Yoshizawa's own folding in other ways. They have used modular and multi-piece folding, geometrical folding, tessellations, highly complex bases and "box-pleating" among many other styles. As the Paris Origami exhibition showed, the world of Origami is now very wide and diverse and has often taken directions of which Yoshizawa has made it plain that he strongly disapproves.

Yoshizawa himself never uses complexity for the sake of complexity or merely as a dazzling display of virtuosity. All his technique is employed as the servant of his art and he has steadfastly held on to his spiritual approach to origami. His own skills and techniques have continued to develop during his lifetime and we have seen how he has adopted more complex bases which have enabled him to fold four-legged creatures from single piece of paper and to give them three-dimensional form and solid backs. He has developed his wet-folding techniques, too. All of this has been directed to achieving a truer likeness and a greater liveliness in his creations.

Yoshizawa fully accepts that whatever technique we use we can never achieve by paperfolding a truly accurate reproduction of a creature. There has to be stylisation and suggestion. But given this, it is remarkable how Yoshizawa brings to life the creature he is folding. He has instructed us to look closely at an animal to see how it is formed, to see its build, its underlying skeleton and structure, how its limbs and muscles lie and the natural poses into which it falls. He strives to avoid surplus creases and to ensure that the creases that he cannot avoid emphasise the natural form of the animal. As a result, his animals and birds have the appearance of life. More than that, he admonishes us to try to get into the inner being of a creature, its character, expression, emotions and humour. In other words, he tries to get into the very spirit of the creature he is folding. It is in this way that Yoshizawa surmounts the mechanical technique of paperfolding and turns folding into art.

The overwhelming impression I have of Akira Yoshizawa is his devotion. It is something of which I have slowly become very aware over many years. Repeatedly he has said that he uses his hands to fold in the service of God and he has often says that he hopes that his folding will help to bring peace to the world. On many occasions I have seen him pray before settling down to fold. Indeed, Yoshizawa has said how he studied Buddhism for two years when he was a young man. But If I had needed any confirmation of his deep and humble faith, I saw it during our visit to the Kensoin Temple.

For me, my visit to Kyoto has served to increase my understanding of Yoshizawa's spiritual nature. Above all, Yoshizawa's is a spiritual art, which has its roots in his deep personal faith. Call it what you will, all art is deeply rooted in the spirit and if origami is to grow and develop as an art form, whatever form that may be, it will necessarily follow Yoshizawa in the approaches and attitudes pioneered by him and by adding something to the folding process something more than the mere physical manipulation of the paper

Yoshizawa has steadfastly pursued this personal approach to folding and his exhibition shows that he has succeeded supremely. Whatever approaches other paperfolders may have and whatever direction or directions paperfolding may take in the future. Yoshizawa's personal achievement of eighty-eight years has been immense. Whether or not origami would have grown and flourished in the way that it has without Yoshizawa is a matter of conjecture. But the historic fact is that Yoshizawa did transform paperfolding and origami will always have its roots in Yoshizawa's achievement. Akira Yoshizawa has secured his place as a giant of origami for all time.

David Lister

15th May, 2000, (revised 20th May, 2000)

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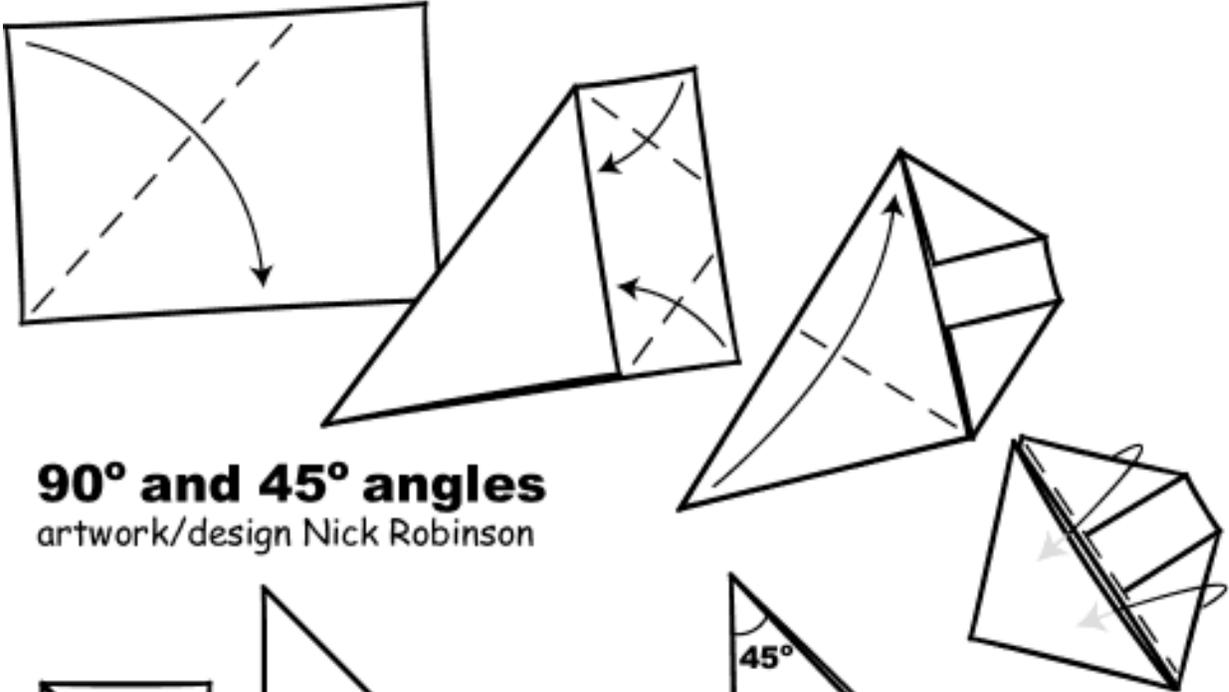


Folding angles of 45 and 90 degrees

by Nick Robinson

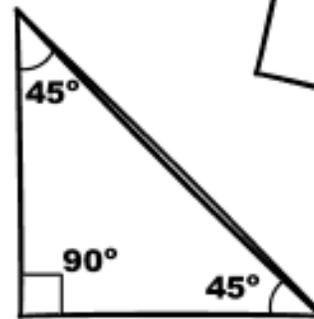
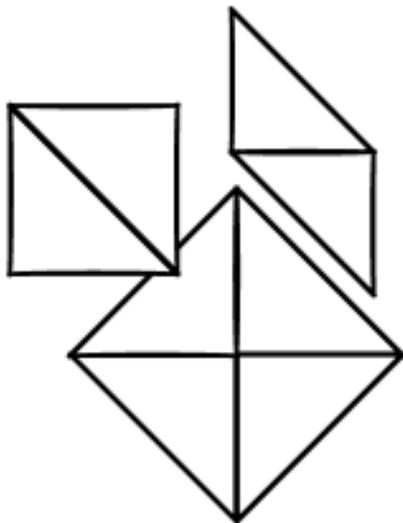


Here is one of the many methods of creating angles of 45 and 90, with non-raw sides. This design can be used to teach many things; accuracy, geometry, folding techniques, combining polygons and will serve practically as either a bookmark or a setsquare.



90° and 45° angles

artwork/design Nick Robinson



Folding angles of 30 and 60 degrees

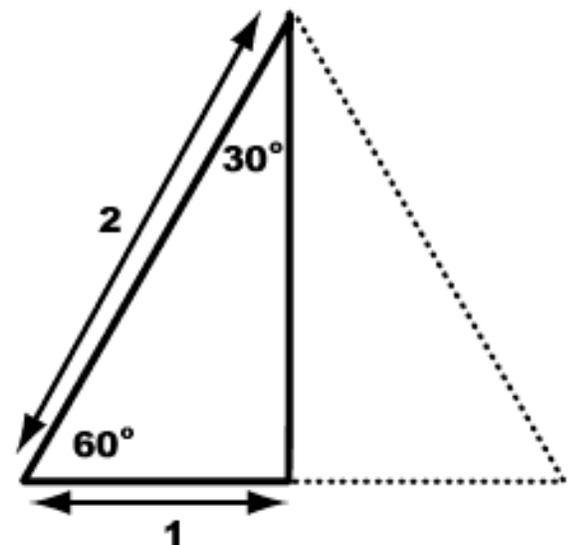


by Ian Harrison

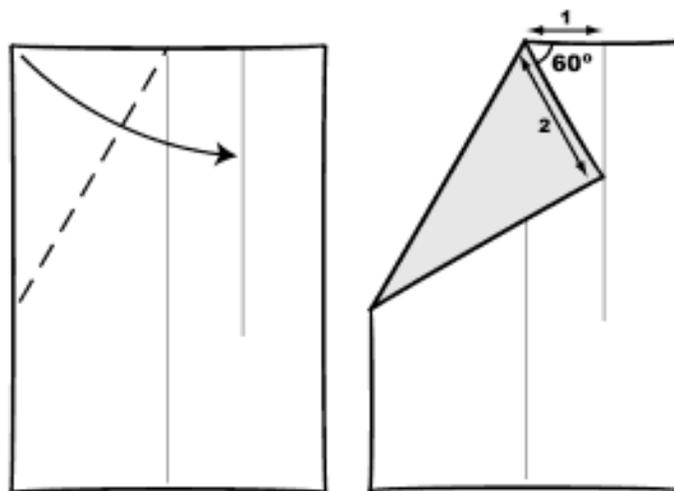
For those of us who fold paper regularly, creating angles of 90 and 45 degrees is almost second nature. We create a right angle by folding an edge, or a crease, back on itself and we can bisect a right angle (or any other angle) by placing the folds that form the two sides of the angle on top of each other. The mathematics of folding angles of 60 or 30 degrees is only slightly more difficult to understand. (The other angles that paperfolders - especially modular paperfolders - often need to construct are the angles of 108 and 72 degrees, useful in making polyhedra with pentagonal sides and other related forms.)

The method of constructing angles of 60 and 30 degrees by folding is based on the symmetry of an equilateral triangle - one that 3 sides of equal length. To make the explanation clear we will use as an example an equilateral triangle that has sides of 2 units long. We need to look at just one half of it.

The longest side of the right-angle triangle that forms this half, its hypotenuse in the language of geometry, is one side of the original triangle and is therefore still 2 units long. The shortest side of the triangle - at the bottom in the diagram - is half the length of one of the original sides and is therefore only 1 unit long. This ratio of 2:1 between the sides is the key to constructing this kind of triangle - and consequently the angles of 60 and 30 degrees - by folding paper. (For those of you familiar with Euclidean geometry, this is a triangle described by the condition 'right-angle, hypotenuse and side' which is a condition for congruence.)

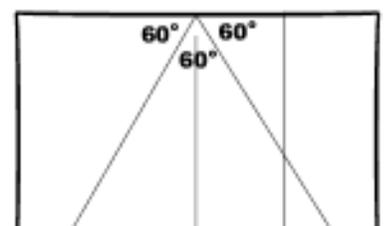


The diagrams below show the classic way to fold an angle of 60 degrees in the middle of the top edge of a rectangle. To do this, first crease the paper in half to mark the centre-line, then fold the left hand edge to the centre-line to crease the left hand half of the paper into two quarters. (Look at the diagrams - it's easier!) To form the triangle - shown shaded - swing the far top corner across to the quarter way fold, making sure the crease starts at the centre line.

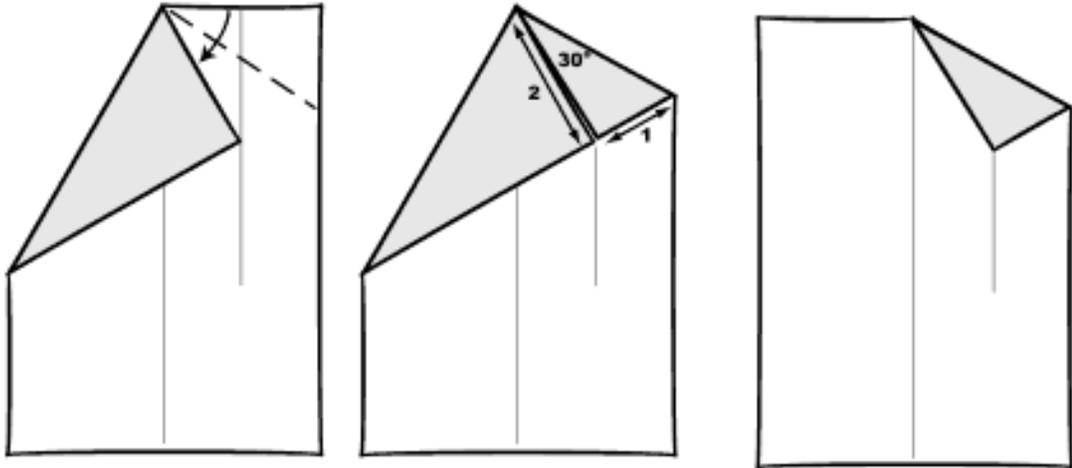


The shaded triangle is an example of the half-equilateral triangle described above. It has a longest side - hypotenuse - of half the length of the top edge of the paper, and a shortest side of one quarter of the length of the top edge of the paper. This creates the ratio of 2:1 we are looking for.

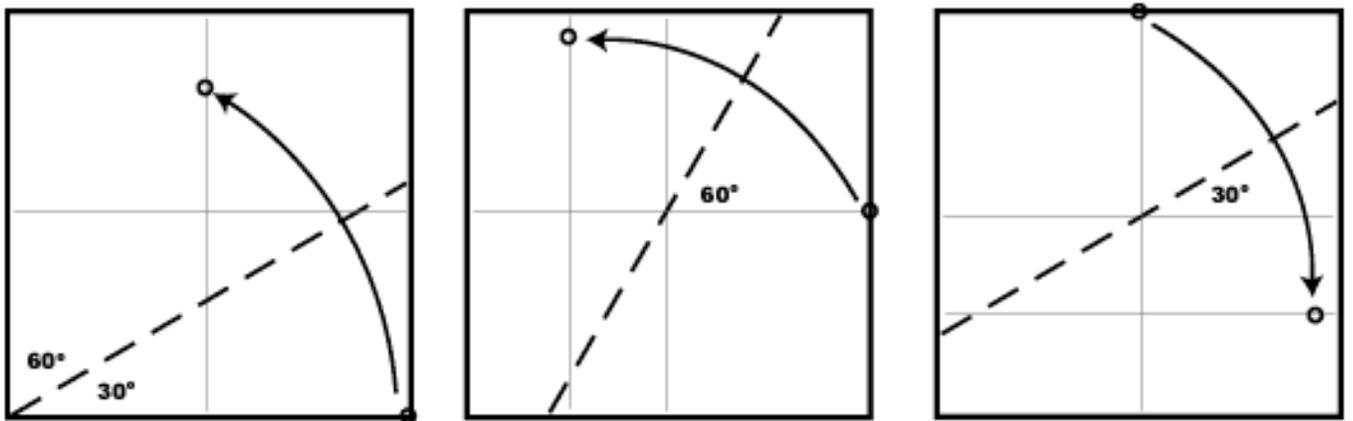
The fact that the angle of the shaded triangle at the centre of the top edge is 60 degrees means that the angle next to it along the edge (it's supplement) is 120 degrees, and this is bisected by the fold that we have made. By folding the left hand top corner over to lie along the first folded edge we can create 3 equal angles, each of 60 degrees, at the centre of the top edge.



Folding the other corner across, so that two raw edges lie along each other, bisects the angle of 60 degrees into two angles of 30 degrees each. Of course, we don't have to make the angle of 60 degrees first. We can simply swing the left hand top corner to the quarter way fold (the third diagram below). Again the shaded triangle has the crucial 2:1 ratio between its longest and shortest sides. This time the angle in the triangle at the centre of the top edge is 30 degrees, so the angle next to it, along the edge to the left (its complement) is 60 degrees, and again, this angle is bisected by the fold that we have made.



With small modifications to these ideas we can fold an angle of 60 or 30 degrees at a corner, or at the centre of a square, like this:

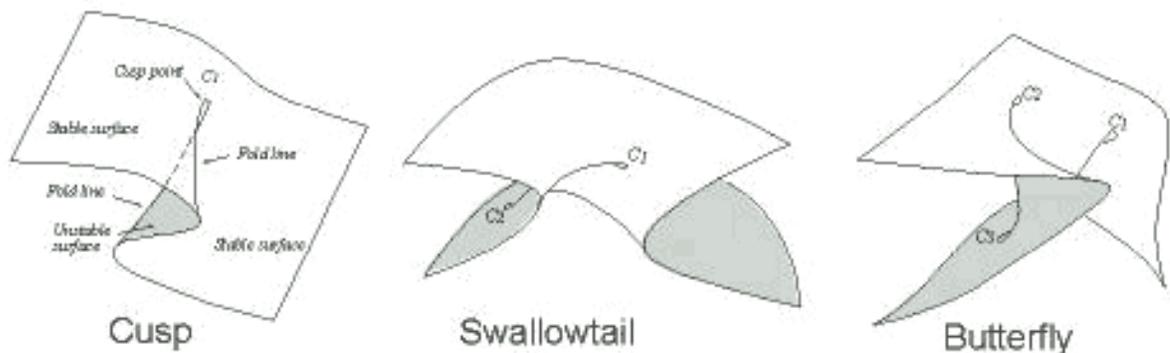


Origami & Catastrophe Theory

by Leong Chen Chit

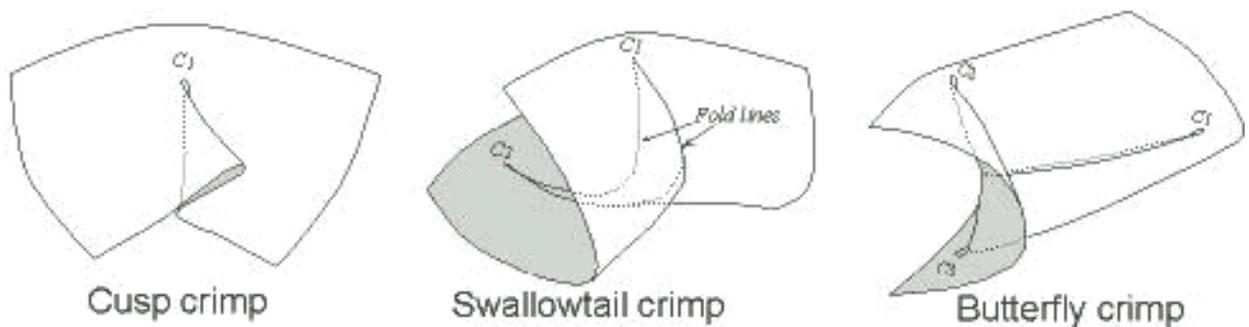
In flat folding, the folds of a model and the model itself are collapsible onto a flat surface. However, some folds, normally formed towards the end, cannot be collapsed onto a plane without having to create additional folds. Examples are the crimp fold and the fold at a corner of a cube model. Whether the folds and the model itself are collapsible or not, the fold lines are straight. In the case of the crimp fold, the fold lines and the surface or surfaces formed by the fold may be curved. The current origami terminology is inadequate for curved 3D origami folds. A convenient and practical way is to borrow the terms applied to the manifolds of Catastrophe Theory, a branch of mathematics.

In Catastrophe Theory, manifolds are used to explain sudden changes in the course of an event due to shifts in environmental factors. The first four catastrophe geometries are 1. Fold, 2. Cusp, 3. Swallowtail, and 4. Butterfly catastrophe. Without going into the mathematics of their geometry, we need only to observe that the Cusp manifold has one cusp point, which is the point of coming together of two folds in a sharp spikelike intersection. The Swallowtail manifold has two cusp points and the Butterfly manifold three. See diagram.

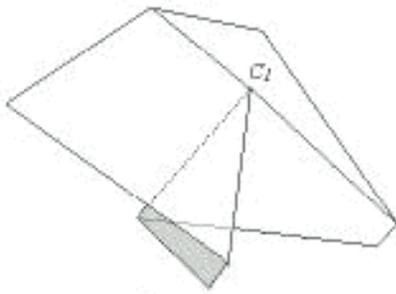


We can translate the first four manifolds of Catastrophe Theory into origami folds. The first one, the Fold manifold, is the equivalent, in flat origami, of the mountain/valley fold. It has no cusp point. The second catastrophe geometry, the Cusp manifold, is the equivalent, in flat folding, of the reverse fold; third, the Swallowtail manifold, is the equivalent of the double reverse fold; and fourth, the Butterfly manifold, the triangular sink fold.

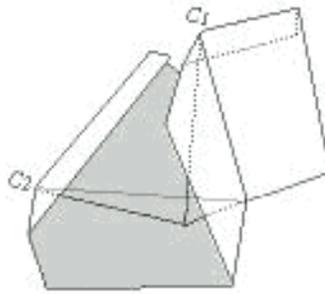
In 3D folding, the fold line of the Fold manifold takes the form of a curve. The fold itself cannot be collapsed onto a plane. Similarly, the 3D paper folding equivalents of the Cusp, Swallowtail and Butterfly catastrophes are made up of curved folds and cannot be collapsed onto a flat surface. The origami 3D Cusp fold has one cusp, the Swallowtail 2 cusps, and the Butterfly 3 cusps.



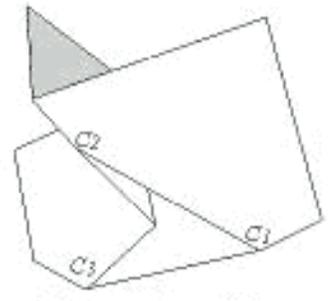
Discounting the somewhat trivial Fold fold, the first three basic folds of 3D origami are, therefore, the Cusp fold, the Swallowtail fold and the Butterfly fold. We can also regard the Swallowtail, Butterfly and higher order 3D folds as combinations of Cusp folds in the same way that flat folds may be regarded combinations of reverse folds. See Diagram.



Reverse



Double reverse



Triangular sink

The use of 3D folds extends the scope of origami and enhances it as an art form. Combining 3D with flat folds produces origami models with less angular and more sculpture-like look. 3D folds are incorporated in several of my origami models, such as the dog bust, right.

Cheers!

Cheng Chit



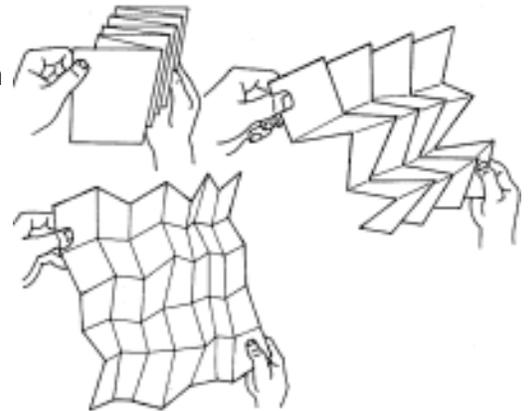
The Miura-Ori map

by Ian Bain

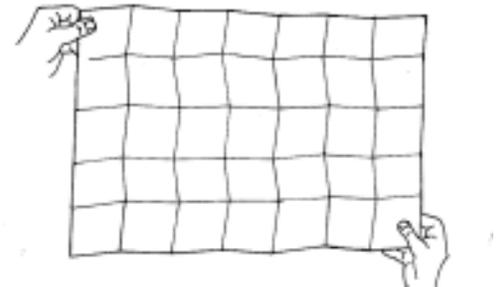


Folded maps are merciless to the user who makes the slightest error in returning them to their compact form. At the Tokyo ICA meeting Koryo Miura and Masamori Sakamaki from Tokyo University's Institute of Space and Aeronautical Science demonstrated an application, of space science, combined with a little Origami, which transforms the ergonomics of map folding.

Miura and Sakamaki normally work on the problems of packing large flat items, like satellite antennae and solar collectors, into the smallest, most compact shapes with a view to deploying them as rapidly and as simply as possible. They saw three problems with maps folded at right angles in the conventional manner. First, an orthogonally-folded map requires an unduly complicated series of movements to fold and unfold it. Secondly, once unfolded there is a strong possibility that the folds may be "unstable" and turn inside out. Finally, right-angled folds place a lot of stress on the paper inducing, almost without exception, tears which begin where two folds intersect.



The key to an alternative system of map folding lies in the ancient Japanese art of paper-folding, origami. One of the most common origami effects is to use a variant on concertina folding to produce a slightly ridged surface composed of a series of congruent parallelograms, by a variation on concertina folding.



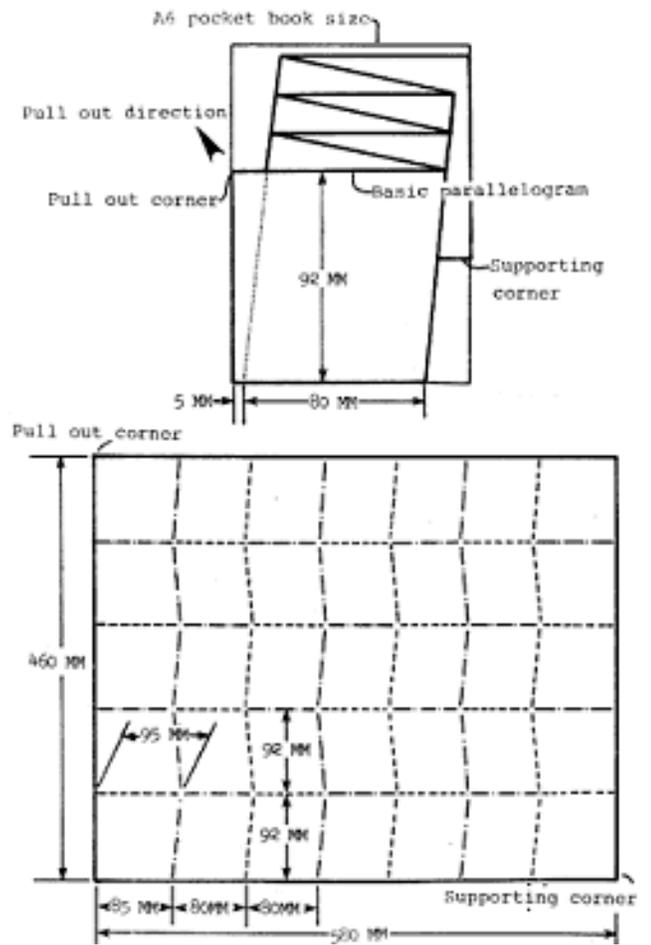
Miura and Sakamaki looked at this kind of surface in terms of its geometry and elasticity and came to the conclusion that the most important point of difference from an orthogonally folded sheet is that the folds are interdependent. Thus a movement along one fold line produces movement along the other. In other words, the user can open the map with just one pull at a corner. The new method also solves in part the other problems which Miura and Sakamaki cited. Interdependence of folds means that it is very difficult to reverse them and the amount of stress placed on the map sheet is also reduced because only one thickness of paper comes beneath the second fold, avoiding the need to fold several sheets. Will it catch on? That depends on commercial exploitation. and the automation of what is admittedly a complicated initial folding process. Miura and Sakamaki have devised a mechanical folder which they coyly term an "origami machine", but they did not reveal its details.

Professor Koryo Miura has since sent us a copy of the paper which was distributed at the International Cartographical Association's conference last August. This may now be borrowed from the library, and makes fascinating reading. The subject of map-folding is dealt with very fully and several of the topics discussed are worth a mention here. Professor Miura examines what he suggests is the oldest folded paper map in existence.

Now in a museum in (Milan, Italy, this comes from Egypt and describes the location of a gold mine in the Nubian district of that country. He looks at the problems of conventionally folded maps which are prone to stress and tearing at their right-angled folded corners. The Miura-on mop avoids this weakness. Diagrams showing the paths made by both right-hand and left-hand thumbs in unfolding the conventional and the Miura-Ori map are compared.

Professor Miura says that on his new map the angle made between the lengthwise-folds and the lines of geographical longitude can be calculated to N, equal to the westward inclination of the magnetic north in most parts of Japan! For those who would like to reconstruct the Miura Ori map, we reproduce a crease pattern diagram from Professor Miura's paper, together with precise dimensions required. For this size fold, the parallelogram angle should be about 84 degrees

This article by Ian Bain first appeared in the 23/10/80 issue of New Scientist, London, the weekly review of science & technology and was reproduced in an issue of British Origami in 1981



If anyone would like to provide an update, please [get in touch...](#)

Other related sites include;

<http://www.u3p.net/tempo/folding/pliage1a.html>

<http://www.orupa-kansai.com/e/product.htm>

<http://library.thinkquest.org/28923/miuraori.html>

