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PAPER FOLDING: A CHALLENGE

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Abstract- In this paper, we present a framework studying problems for folding the paper into equal halves. The framework proposed is used for studying and analysing the issues which will come during folding the paper through simulation. The developed simulator has the facility to allow alternative direction and single direction of paper folding. The thickness and the width ratio are also calculated. An important feature of this approach is allows us to study fold ability. That is one object be folded or unfolded into another object, but it also provides us with another investigating dynamic folding process itself. The experimental results with paper folding are quite encouraging.
Keywords- Paper, Simulator, Alternative direction, Single Direction, Complexity, Application, Analysis, Origami.

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Introduction

Folding is very common process in our lives, ranging from the macroscopic level – paper folding or gift wrapping. In most instances while one desires a particular final state to be reached, the knowledge of dynamic folding process used to reach a particular state is of interest as well. The problem of folding (and unfolding) has been studied in several application domains. We begin with related work and concluding with Final results

Related Works

In this section, we first survey the research work that related with different mathematical analysis of paper folding. We next present some related work on paper folding, packaging, cartoon folding and metal bending, and then consider work on paper folding simulator.

Mathematical Analysis of paper folding

Assuming it were possible to fold paper without restriction, the height of the piece of folded paper would double in thickness each time each was folded. Since one sheet of typical A4 size of paper has a thickness of about 0.1 mm, folding 50 times (if this worked physically possible , which offcourse it is not) would produce a wad of height 1.13 X 10^{11} m, and folding 1 more time would make the stack higher than the distance between the earth and the sun.[1]

The function :

$$L = (1/6) *(\pi^* d) (2^n + 4) (2^n -1)$$

Gives the loss function for folding the paper in half, were **L** is he minimum possible length of the material, **d** is the thickness, and **n** is the possible number of the fold in a given direction. This formula indicate how much “normalized” paper has been lost for n folds, and thus sets a limit for the number of times things finite thickness can be folded in one direction. For n=0,1,2,3,...............the sequence L/(π*d) gives 0,1,4,14,50.186,174,.......the formula was defined was derived by high school student Britney then proceeded to set a new world record by folding first gold foil and then paper in half whooping 12 times in January of 2002.[3]

Packaging and computational geometry: Paper Folding

Products are frequently packaged into cartons at the end of an assembly process. Often flat sheets of cardboard are folded into cartons. This task requires dexterous manipulation and is usually done by the human operators. Lu and Akella, consider a carton folding problem with fixtures and its application in packaging and assembly. There are also systems and designs that produce three-dimensional metal parts by bending blank sheets. There is need for techniques to generate folding or bending sequences. For example, a system is described to automatically generate bending sequences for sheet metal products.

Many problems related to folding and unfolding of polyhedral objects have recently attracted the attention of the computational geometry community. one class of problems concerns itself with the constructability of certain polygonal or polyhedral structure. Several interesting algorithmic questions related to origami have attracted the attention the computational geometric, who have obtain some remarkable result. e.g. answer a long standing open problem in origami design by showing that every polygon region (with holes) is the silhouette of some flat origami, They also show that every polyhedron can be wrapped by folding a strip of paper round it, which address a question rising three dimensional origami. e.g. There a number of other interesting questions related to three dimensional polyhedral object. For instance, can every convex poly tops surface be unfolded to unknown overlapping simple polygon by cutting along its adjust. This problem has application in manufacturing parts from sheet metal. Real applications are more concerned with non convex polyhydric where results are only know for some particular classes of polyhedral. The inverse problem of folding a polygon into a particular polyhedron is has been studied, and results have been obtained for special cases.

Although the problems discussed above can be modelled as articulated objects, in most cases origami problems cannot be modelled as trees. In particular the incident faces will form a cycle in the linkage structure.

Simulator for Paper folding and its results.

Why Simulator?

Designing the simulator for paper folding problem is a challenge. The paper folding simulator is the result of feedback from many channels and reducing the actual process of experimenting the paper fold. This process requires the huge time, effort, resources. The simulator is most effective learning tool most closely approximating and experience the real world problem.

Which language should select while design the simulator?

The answer to this question is very straight forward which available easily and having the facility to give correct, efficient and effective result. Microsoft Visual Studio 2010 express edition is freely available. The C# is the language which is having Rapid application Development feature. It allows the n-tier application development. If we compare C# over other C# is safer to run.

Simulator Design

As in figure 1 the simulator is having very rich controls like grid text boxes, combo boxes etc. The total two grids are used The bottom gird are for measuring and counting the pieces of paper after each and every fold. The second grid is exclusively used for showing the length, width and height after each and every fold. The simulator accepts Length, Width and height in millimetre (mm), inches (inch) and meters m. The transaction group is allowed to select the paper folding approach.

Working of Simulator

The simulator allows to enter the length, Width and height of the paper along with the dimension in mm, inches and meters once entered all data no need to provide more data to the simulator. As the part of transaction the simulator is having the facility for single direction and alternative direction methods for folding. Remember there are two different method of paper folding each are having different method. The desire limit of paper folding using a single direction can be calculated using the formula:

$$L = (1/6) *(\pi * d) (2^n + 4) (2^n - 1)$$

Where,

L - Possible length

d - Thickness

n - Possible fold.

At the other hand the paper folding using alternative direction have the limit

$$W = \pi * t\ 2^{3(n-1)/2}$$

Where

W - Width

T - Thickness

n – Possible Fold

The simulator allows as to jump at any fold and it shows the result immediately.

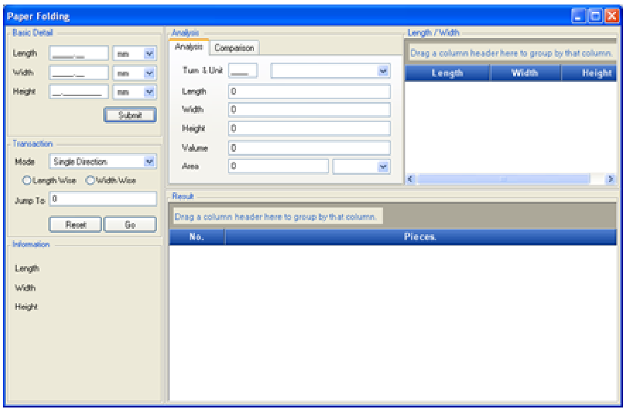

Fig. 1-

Results

While designing the simulator we notice when we started the paper to fold exactly half then the results are in $\mathbf{2^n}$ form.

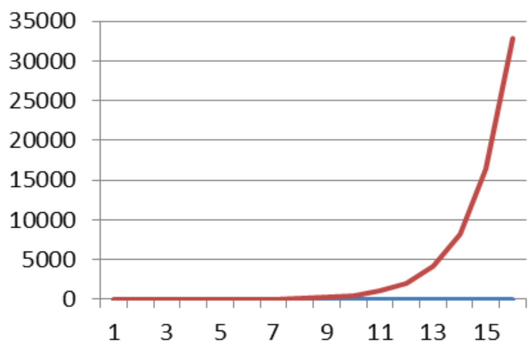

Fig. 2-

The X- Axis represents the number of folds and Y – Axis represents the folded piece of paper.

We use the same for our simulator for finding the number of folded paper pieces during the turn.

The beauty of the simulator is it allows as 20,000 folds the result is very huge (not in terms of 10 it is a real figure). The following figure shows the pieces of paper after 10,000 folds.
Using simulator we will get some exciting result if we started folding the paper , the height of a piece of folded paper would double in thickness each time it was folded. Since one sheet of A4 size of paper which is having the thickness of about 0.1 millimetres (mm) folding 50 times would produce a wade of height 1.13 X 1011 meters, and folding one more time would

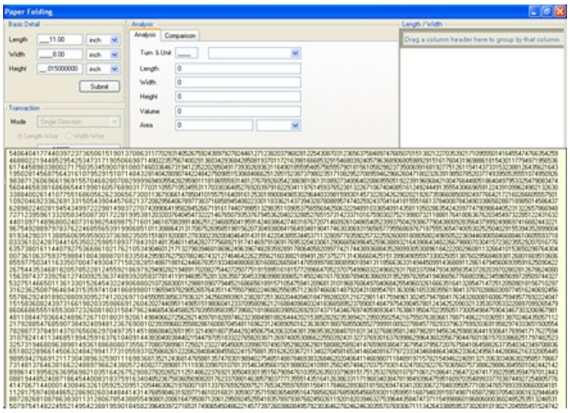

Fig. 3-

Conclusion
In this paper we are presenting the solution of paper folding problem using simulation method which gives the no. of fold, growth rate, angle and the width, length of the paper from the folded area which allows you to visual the actual problem which will occur during the real implementation .
The maximum number of paper folding record goes to Britney and only have the person which folded a piece of paper in half 9, 10, 11 and 12 times. The method used for paper folding is based on principles of mathematical geometric progression.

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Shaikh Z.M. presentably working as Assistance prof. in department of CSE , He completed his Masters in Computer Engineering and having 6+ years in IT industry and remaining 5 years is in teaching . He is having the expertise in Image Processing and Programming languages.
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