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Screen design: a dynamic symmetry grid based approach

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Abstract

This paper extends the study of dynamic symmetry as a screen layout technique. Research in the past was based on manually designed screens with minimal software support. This paper formulates the manual process into algorithms. Empirical results based on the study are presented. One study reformats user proposed layouts automatically while the other employs system grid interaction with users during design-time. Analysis of viewer selections yielded an average of 67.86 and 73.33% for those preferring dynamic symmetry screens over the originals. These experiments showed that incorporating dynamic symmetry into screen design tools can affect user's perception on interface aesthetics.

Keywords: Screen design; Screen aesthetics; System of proportion; Dynamic symmetry; Grids

1. Introduction

1.1. The importance of screen design

Developers have been designing screens since a cathode ray tube display was first attached to a computer. Screens then were cluttered and lacked visual organization until the 1980s when guidelines for text-based screen design were made widely available [1,2]. Through concepts like grouping and alignments many screens began to take on a much less cluttered look. The advent of graphics yielded another milestone in the evolution of screen design, providing many alternative ways of interacting with a computer system through the screen. Graphic ingredients enabled considerable presentation enhancements, making screens easier to understand and use. The bloom of multimedia and the World Wide Web during the 1990s made aesthetics even more crucial as this concept benefits usability and soft issues such as user motivation and long-term satisfaction [3,4]. However, aesthetics then was mainly subjective in nature with minimal scientific and objective basis. The 1990s and the dawn of the millennium saw the emergence of scientific research in the aesthetics of object-based screen design [5–11]. These studies share a common goal to discover more intrinsic determinants of interface aesthetics, which may have an overriding effect on purchase or usage decisions. For example, Tullis [12] derived six measures that can be used to describe the spatial arrangement of characters on any alphanumeric display: overall density, local density, number of groups, size of groups, number of items and layout complexity. Ngo et al. [9] on the other hand proposed 13 measures for evaluating graphical screens: Balance, Equilibrium, Symmetry, Sequence, Cohesion, Unity, Proportion, Simplicity, Density, Regularity, Economy, Homogeneity, and Rhythm.

1.2. The use of grid in screen design

The grid is the conceptual embodiment of the design program [13]. It allows the discovered determinants to be codified and propagated consistently across a series of screens in a GUI. A grid is the geometrical division of a space into precisely measured columns, spaces and margins; it is the backbone of screen design. Composing and designing spaces with a grid have become an essential tool for the practicing designer [14]. Jude [15] states that 'the primary purpose of the grid is to create order out of chaos; it is an aid to readability, recognition, and understanding.' In laying out a webpage, for example, the use of a grid was encouraged [16] so that similar types of pages have a similar look and feel, creating grids for page types during the planning phase of a project saves development time and helps ensure consistency throughout the site [17]. Grids also assist designers in creating good compositions according to Waters [18]. Waters in *Web Concept & Design* mention that

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'[grid] helps to blend the linear formality of type with the flow of photography or illustration and it guide a viewer's eye through a page.' Grids enable the designers to have greater control of visual elements while in the process of designing.

A recent study [19] on the use of grids and guides by 30 inexperienced users showed that 23 found grids to be useful. Twenty-three out of the same group also voted that interface design without grids is a difficult task. In the same study, more than 53% of the participants have used grids for interface layout assistance such as symmetry, balance, alignment, and element positioning. A number of them have even discovered the use of grid for beauty, flow of design, and harmony.

1.3. The use of modular systems in screen design

Currently, popular screen design tools provide an option for users to specify the width and height of grid units. This customizable option is useful to a certain extent, however, when designers require assistance in aesthetics, they will need to depend on the integrity of their sense of form. Inexperienced designers on the other hand will find the task to be intimidating. In order to override this often-difficult task, HCI research community has been exploring better methods. One important attempt is the use of the golden section for screen design. This modular system occurs in a variety of natural forms and is considered visually pleasing to a variety of cultures [20]. Offline artists and designers such as Leonardo Da Vinci for example uses the grids of the golden section to segment his drawings into proportional parts while Le Corbusier uses golden section grids in his red and blue series for architectural designs. In recent years, many screen designers have adopted the golden section and its grids for screen layouts while others have attempted to introduce it as a screen design tool [8,21,22]. Gait [21] used golden section in Pretty Windows to transform windows of arbitrary dimensions to the dimensions of a golden section rectangle. Others like DON [23] lets designer modify the shape and size of layouts with the default ratio of the golden section.

Another method termed Dynamic Symmetry discovered by Jay Hambidge was first used in VISIT [8]. This proportioning system has its origin from the law of natural design based upon the symmetry of growth found in nature [24,25]. The system uses a number of aesthetic rectangles such as the square, root-two, root-three, double squares, and root-five as its design principle. VISIT introduced this classical modular system as a template-based screen design tool, which provides dynamic symmetry layouts serving as shorthand for helping designers to find an effective format for their information. In a recent technical report [26], Ngo and Ch'ng discovered that dynamic symmetry was unconsciously used by experienced designers whose sense of form is highly developed. The study examined whether dynamic symmetry has been applied to screen design in the past. In the report, 150 screens representing a wide variety of design characteristics were sampled and Hambidge's method of analysis was applied to determine whether any of them could be analyzed in accordance with the principles of dynamic symmetry. Of the many examples of screen design which have been examined, about 75% show dynamic schemes based Hambidge's technique. These results are quite surprising given the expectation that their designers were not aware of dynamic symmetry. Perhaps there is no simple, easy explanation beyond assumption that the laws of proportion are, in some strange way, inherent in visual perception. Without being taught, designers have gravitated to the fundamental shapes of dynamic symmetry for centuries. Presently, it is difficult to define what makes the shapes so naturally pleasing. But, it is interesting to note that in natural and human inspired design, the dynamic proportions show up over and over. By using this information, we are able to determine how to lay things out in a visually pleasing way. It can also give parameters for computer displays. In this paper, we take the concept used in VISIT a step further and developed an expert dynamic symmetry enhanced gridding system for screen design that could be used to help non-designers format screen layouts. It uses information such as the positions and sizes of a set of graphical objects to generate design grids based on the dynamic symmetry technique. In particular, we introduce the base grid and object grid as two key concepts for dynamic symmetry screen design. Base grids are grids generated based on frame size and is used as initial guides for object placement. Object grids on the other hand are grids generated based on screen layout details.

The paper begins with an introduction to the concepts of dynamic symmetry in Section 2. In the sub sections, we detail Hambidge's dynamic symmetry technique and present our methodology for dynamic symmetry grid design in a design environment called Dynamic Symmetry Gridding System (DSGS). In Section 3, we review the results of the empirical studies validating the grid design method in two experiments. Finally, the paper concludes with a summary of the contributions and future work.

2. Dynamic symmetry grid design methodology

Dynamic Symmetry, the proportioning system widely used in the flourishing period of Greek design was rediscovered by Jay Hambidge in the 1920s [25,27–29]. In his painstaking measurements of vases in North American museums, Hambidge demonstrated his rediscovery of the use of the golden section and root rectangles in ancient Greek artistic design. This proportioning system utilizes proportions from the human figure, the growing plant, and the logarithmic spiral curves of shells as its design principles. In his study, it was discovered that there were two types of symmetry in both natural and artificial design defined as static and dynamic symmetry. The rational

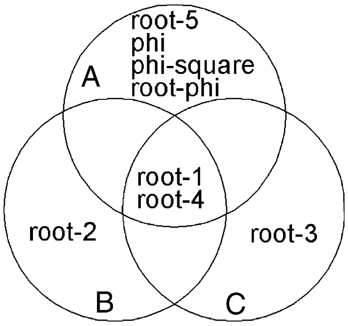

Fig. 1. Relationships between dynamic rectangles.

numbers such as 3/2, 5/4, 8/5, 3, etc., belonging to the measurements of the width and height of rectangles or its divisions are called static rectangles. Rectangles of the superior dynamic type with irrational numbers in their proportions such as $\sqrt{2}$, $\sqrt{3}$, $\sqrt{5}$, $\phi = (\sqrt{5}+1)/2$, $\sqrt{\phi}$, $\sqrt{\phi^2}$, are called dynamic rectangles.

2.1. Hambidge's technique

A technique taught by Hambidge when applied to any dynamic rectangles forms a pattern where only certain rectangles of the same theme co-exist. This conception of thematic proportions in a composition is the unique aspect of dynamic symmetry not found in other modular systems. By using the technique, 'The tracing of diagonals and perpendiculars to diagonals' on a dynamic rectangle, the themes of dynamic symmetry is formed where certain classes of rectangles are related only to themselves and can be used as a group only in the same compositional layout. This notion of relationship between the proportions of rectangles derives its importance from a law of composition already mentioned by L.B. Alberti, the 'law of the non-mixing of proportions or themes in a plane composition'; in such a composition, only 'related' themes must be used, 'antagonistic' themes must not be mixed. A law in Hambidge's technique derives a principle in which the dynamic rectangles $\sqrt{5}$, $\sqrt{\phi}$, $\sqrt{\phi}$, $\sqrt{\phi^2}$ formed the same theme, $\sqrt{2}$ and $\sqrt{3}$ will not unite with themselves, and $\sqrt{4}$ and $\sqrt{1}$ are the neutral types which can be used with any of the other groups. Fig. 1 shows the relationships between these rectangles. The set A consists of a theme belonging to one group, and B and C are two other themes consisting of two different groups. Fig. 2 illustrates dynamic rectangles 'treated' by Hambidge's technique for sets A, B, and C in their themes.

The theme in Fig. 2(a) clearly showed a more flexible surface for set A compared to B and C. This was discovered in Hambidge's analysis, 'Of the many hundreds of examples of classic Greek design which have been examined in both the American and the European museums, about 85% show dynamic schemes based upon $\sqrt{5}$; about 10% upon $\sqrt{2}$, 1 or 2% upon $\sqrt{3}$, and the remainder are either uncertain or are clearly static.' In another paragraph, Hambidge stated that 'the $\sqrt{2}$, $\sqrt{3}$, and $\sqrt{4}$ rectangles represent, apparently, a symmetry type intermediate between the static and complete dynamic types' [29].

Fig. 2 also shows that dynamic rectangles can be combined to form compound dynamic rectangles with two or more dynamic rectangles of similar theme in co-existence. Fig. 2(a)–(c) are all compound dynamic rectangles and within them are groups of compound types of the same theme. Each of these compound types can act as a base for screen layout. The properties of dynamic symmetry shown in the figures are very suitable for screen design of various characteristics as the thematic attributes remain the same for all of the proportions. This characteristic can create harmony, the pleasing interaction of parts in a screen composition and 'the recurrence of the same proportion in the elements of the whole' [24].

For purposes of design, the most important element of a rectangle is its diagonal. The element of a rectangle second in importance to the diagonal is the diagonal of a reciprocal [25]. Ghyka's *Practical Handbook of Geometrical Composition and Design* [24] mentioned Hambidge's use of a technique of harmonic sub-divisions of the square and of the dynamic rectangles by the tracing of diagonals and perpendiculars to diagonals. Hambidge's method takes into consideration the fact that the overall frame of a two-dimensional plan or composition, whether architectural, pictorial or decorative, is generally a rectangle or a complex of rectangles; in his method of harmonic subdivision, these rectangles are 'treated' by the diagonal.

Fig. 3(a) is an illustration of Hambidge's technique. AC is a dynamic rectangle; from D draw a diagonal to the opposite angle at B. From C draw a diagonal perpendicular

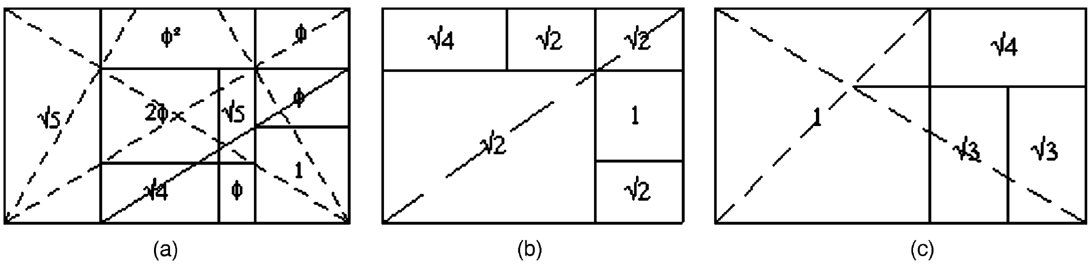

Fig. 2. Dynamic rectangles forming themes.

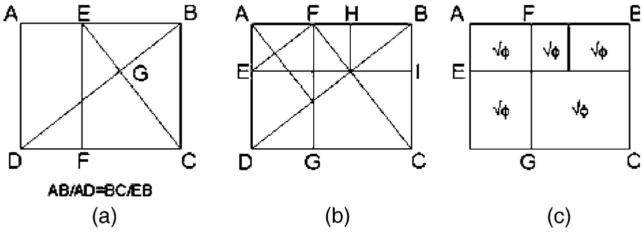

Fig. 3. Harmonic subdivision of a $\sqrt{\phi}$ rectangle.

to DB passing through G at E. AC is the parent rectangle and FB is the reciprocal of AC, both are similar in shape. An important property of this method is that the perpendicular to the diagonal produces inside the original rectangle a smaller rectangle similar to it. If this process is continued with many variations (b), every diagram obtained is what Hambidge calls a 'harmonic subdivision' [24], that is, produces a perfect commodulation of surfaces. A rectangle based on the employment of this method, however, complicated the variations are, fulfils the requirements of the principle of this system [25]. The subdivisions within (c) have the same theme as the parent rectangle. Fig. 4 illustrates the harmonic subdivisions in the theme of set *A* for squares and golden rectangles. Notice that the square and the golden section rectangle each have four different surfaces produced from different subdivisions. This is but a fraction of the surfaces dynamic symmetry techniques is able to generate.

3. Our method

Hambidge's literatures provided us with practical constructions of various subjects from the industry as well as how the Greeks constructed their dynamic symmetry artworks. Two practical examples of design by Hambidge are the lion head architectural decoration and the chair [29]. Observations in his design process yielded a generalized algorithm below:

1. User selects a dynamic rectangle as the desired drawing base
2. The base grid is drawn on the base with the diagonal technique
3. As the user positions design elements on the base, draw the nearest possible secondary grids around the sides of the elements
4. Resize and reposition the elements to fit the grids

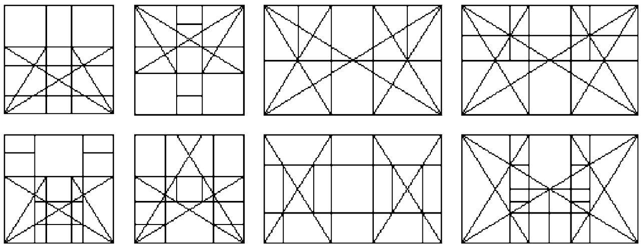

Fig. 4. Harmonic subdivisions of the square and the golden rectangles.

Adopting Hambidge's process and construction techniques, a revised general algorithm for screen design is given below:

1. User propose a screen frame
2. If the screen frame is not dynamic, adjust the screen ratio to fit the closest dynamic rectangle
3. Draw base grid on the frame
4. As the user positions screen objects on the layouts, draw the nearest possible object grids around the sides of the objects
5. Resize and reposition the objects to fit the grids

To develop an automated DSGS, it is necessary to understand the manual process of laying out a screen. Dix et al. [4] advices on the three possible organizations of controls in designing an interface, they are functional controls, sequential controls and displays, and frequency controls. The rule is that 'Aesthetic placements of screen objects should not replace logical grouping of controls… Redesigning a screen with aesthetics must maintain the logical placements and usability of it.' Through experimental study on manually designing screens with dynamic symmetry [5], and knowing the organizations of controls such as those stated by Dix et al., usable dynamic symmetry screen design can be achieved. The process of designing a web screen is observed in Fig. 5.

In Fig. 5(a), a dynamic rectangle frame is proposed and the base grid is drawn at the intersection of the diagonal lines. Fig. 5(b) places the screen objects in a functional layout and possible object grid is drawn as near to the sides

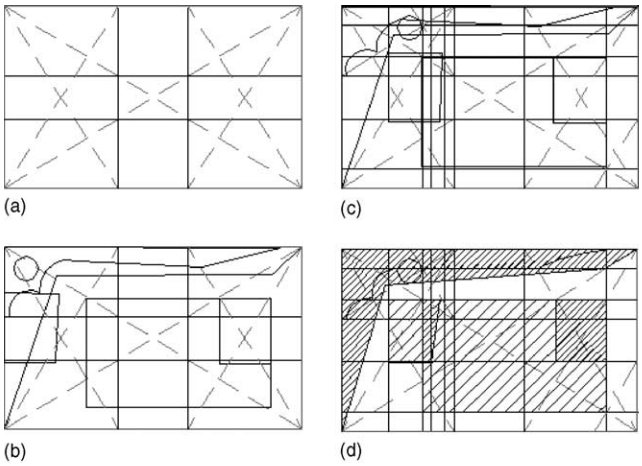

Fig. 5. Manually designing a screen with dynamic symmetry grids. (a) Draw the base grid with regulating lines. (b) Screen objects are placed onto the layout. (c) Object grids are drawn around the sides of the objects. (d) Objects are resized and repositioned to fit the grids.

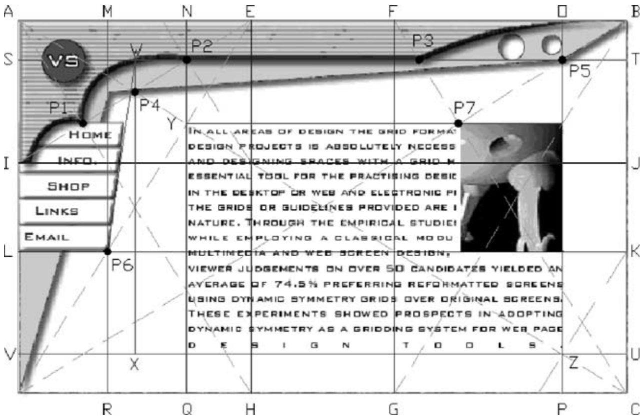

Fig. 6. Dynamic symmetry design on a model web page.

of the objects as possible; (c) in the process screen objects (hashed to differentiate from the grids) are adjusted to fit the grids (d). (c) and (d) are separated to show the difference. The final layout can be seen in Fig. 6. This process is similar for designing multimedia interfaces and all GUI based screens.

Through experimental studies of manually designing screen layouts with dynamic symmetry, it is observed that the design process and Hambidge's technique can be automated through a series of algorithms. These algorithms have much to do with generating dynamic grids and matching screen elements to the generated grids. Grid generation and screen object grid match requires the input of values, processing of the values, and returning the output in a visible screen layout.

Dynamic symmetry grid generation have different processes for horizontal and vertical frame cells. A frame cell is a subdivision within a frame (Fig. 7). Cell A of Fig. 7 is a horizontally orientated cell; Cell B is a square cell, grids for square cells can be obtained by taking its sides, therefore whenever a cell has sides of the same length, grids are not generated. Cell C and D are vertically orientated. A given screen frame may be a cell by itself, or may contain numerous cells within the divisions.

For any given cell, the top-left (X_1, Y_1) and bottom-right (X_2, Y_2) points are read to the algorithm with the number of

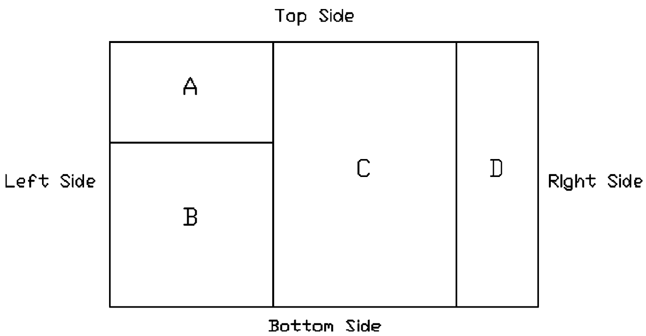

Fig. 7. Frame and frame cells for grid generation.

grid sets to generate for a grid group. A grid set has a horizontal and a vertical grid. A grid group can have many grid sets. By default a grid group has one grid set consisting of a vertical line and a horizontal line. The height and width of the cell is measured from the points and compared for vertical or horizontal grid generation.

In a given cell (Fig. 8a), the intersection of the perpendicular with the major diagonal produces grid lines in the sequence from the first gridline $N_1 - N_n$, where n is the number of gridlines. N_1 and N_2 is the first grid set belonging to the first group and N_3, N_4 belonging to the second group. The unfilled circle showed the intersection of the perpendiculars where the grid lines originate. In (b), the completed grid sets resulting from taking the intersection of the diagonals is denoted by N_1, N_2 and N_3, N_4 where the odd numbers in n are vertical grids and the even numbers are horizontal grids. The grid group is then mirrored to complete the grids shown in (c) as dashed lines.

In Fig. 9(a), grid generation for a vertical cell begins from N_1 to N_n, where n is the number of gridlines. The unfilled circle showed the intersection of the perpendiculars where the gridline extends. N_1 and N_2 is the first grid set in the grid group and N_3, N_4 is the second set. In (b), the completed grid sets resulting from taking the intersection of the diagonals is denoted by N_1, N_2 and N_3, N_4 where the odd numbers in n are horizontal grids and the even numbers vertical. The grid group is then mirrored to complete the grids shown in (c) as dashed lines.

As mentioned earlier (Fig. 5), a screen designed with dynamic symmetry will require two sets of base grid group with a grid set in each group (Fig. 10a) and an object grid, both of these use the same method for grid generation. Passing two points of a screen frame (X_1, Y_1) and (X_2, Y_2) to the algorithm generates the first set of base grid. The values of X_1 and Y_1 is 0 and the values of X_2 and Y_2 is the width and height of the frame, respectively. Because screen objects have different sizes, secondary base grid is needed to ensure a wider range of grid match for loosely placed screen elements. Secondary base grid is generated based on the bottom-right and top-left quadrant of the frame (Fig. 10a). Grid generation for the top-left quadrant receives the values (X_1, Y_1) and (X_2, Y_2) where X_1 and Y_1 is 0 and X_2 and Y_2 is half the width of the frame and half the height of the frame, respectively. The bottom-left quadrant receives the values (X_1, Y_1) and (X_2, Y_2) where X_1 and Y_1 is half the width of the frame and half the height of the frame and X_2 and Y_2 is the width and height of the frame, respectively.

An object grid is generated by matching the object boundaries with the nearest base grids shown as single arrows from the hashed object in Fig. 10(a), matching base grids are then extended to the next possible grid in each direction shown as double arrows. The extension ensures grid generated to be nearer to the object. The object grids are generated in the same way as secondary base grids for the top-left and bottom-right quadrant of the extended grids

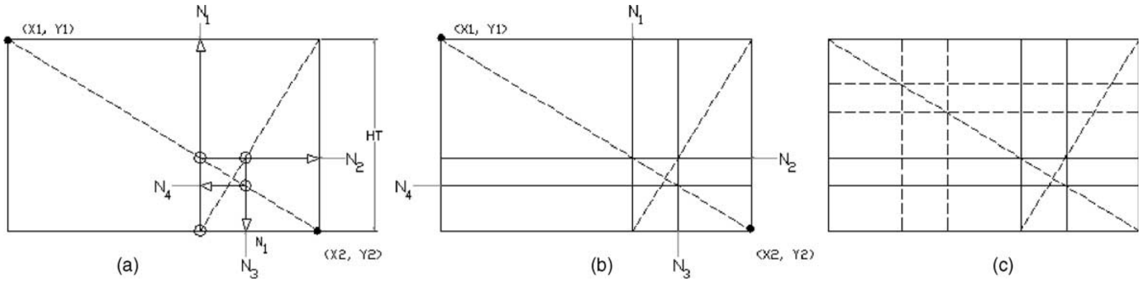

Fig. 8. Sequence of grid generation and mirroring of grids in a horizontal cell. (a) The process of drawing gridlines from the perpendicular diagonals. (b) The completed gridlines. (c) The gridlines mirrored to complete the process.

shown in (b). The screen object then conforms its shape to the nearest available grids (c).

The algorithm provides a way to dynamically generate grids that conform to the law of dynamic symmetry themes based on screen frames, object shapes, and object placements. Different object positions and shapes produce different sets of grids with surfaces that conform to dynamic symmetry proportions. The algorithm formulated in this section lays a foundation for implementation in user interface development environments.

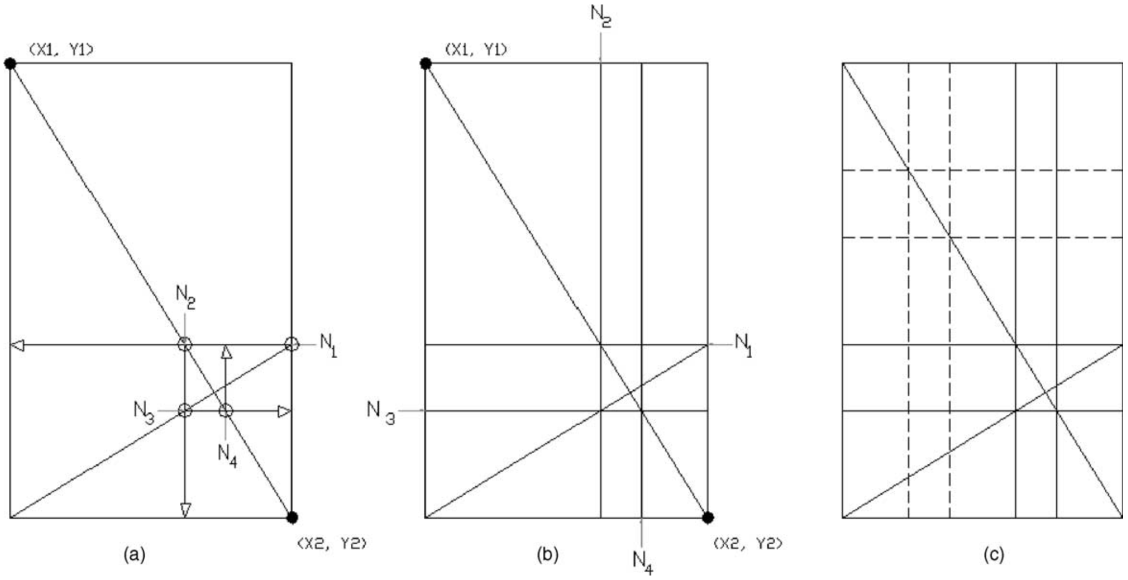

Fig. 9. Sequence of grid generation and mirroring of grids in vertical cells. (a) The process of drawing gridlines from the perpendicular diagonals. (b) The completed gridlines. (c) The gridlines mirrored to complete the process.

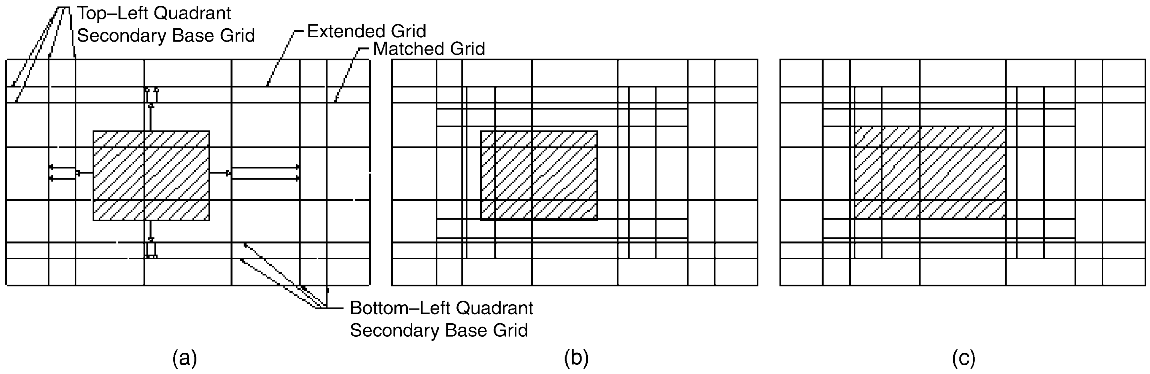

Fig. 10. Grid generating, matching and object fitting process. (a) Matching object boundaries with base grid for object grid generation. (b) Generated object grid. (c) Screen object conformed to object grid.

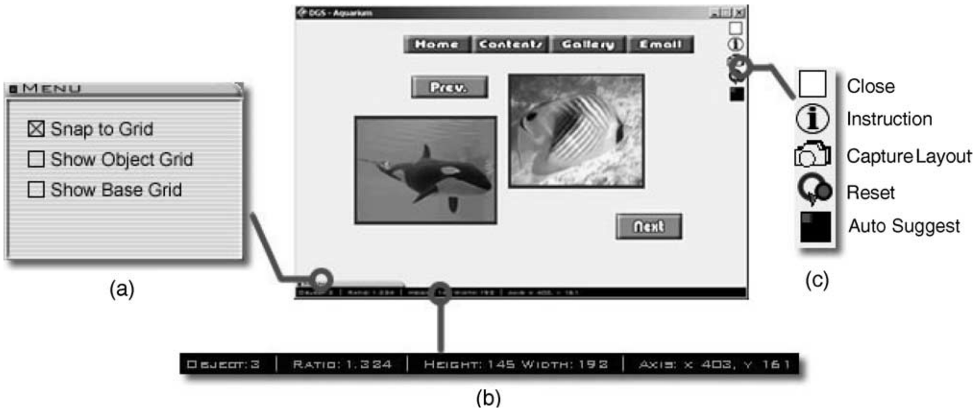

Fig. 11. Dynamic Symmetry Gridding System (DSGS) Interface. (a) Slide menu with grid features. (b) Status bar showing object information. (c) Icons for access to functions.

3.1. Our system

We implemented the dynamic symmetry grid generating algorithm into a system with the necessary interface objects as shown in Fig. 11.

Fig. 11(a) is a menu which slides out to show grid related features. Snap to grid allows users to position, resize, or reshape an object by interacting with the grids. The two other items changes the visibility of the object and base grid. Fig. 11(b) is the status bar showing the information of an object such as the ratio, height, width, and position. Fig. 11(c) shows the icons for instruction, layout information capture, reset, and the auto-suggest screen layout feature. The system allows two ways for dynamic symmetry screen layout—the automated approach and the interactive approach. In the first approach, the user proposes a desired layout and allows the system to generate object grids and automatically reshape and reposition the screen objects based on the nearness of the boundary in relation to the grids; this is accomplished by pressing the Auto-Suggest icon after the layout is done. In the second approach, the Snap to Grid feature is enabled to allow the user to interact with the object grid. Interacting with the object grid is carried out by directly manipulating the properties of the screen object with the mouse such as the position, size and shape information. The system architecture showing the high-level modules of DSGS is shown in Fig. 12.

4. Empirical studies of DSGS

In a previous study [5], screen layouts designed manually with dynamic symmetry were viewed more positively by evaluators as compared to their original versions. The empirical studies in this paper are based on the DSGS that automates the design process by using the algorithms described in the previous section. The system automatically generates dynamic symmetry grids based on the layout details of a screen such as the object positions, sizes, and ratios. The DSGS is designed to assist users in suggesting dynamic symmetry shapes for their layouts with dynamic

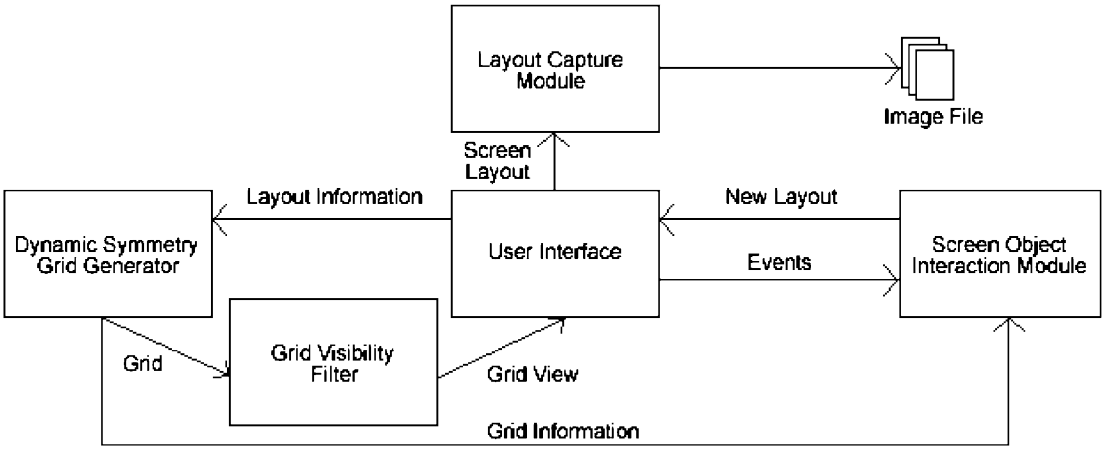

Fig. 12. Dynamic Symmetry Gridding System (DSGS) architecture.

Fig. 13. Original screen and system reformatted screen. (a) Original screen by user. (b) System-reformatted screen.

symmetry grids yet retain minimal changes to their personal preferences.

4.1. Experiment one: automated approach

In the first study, four users were asked to design a dummy screen within the system window by placing the five default objects in a position that the user deemed best, this is done without the assistance of dynamic symmetry grids. The users were first given 1 min to get familiarize with the interface functions such as scaling, reshaping, and moving of the screen objects. When the objects are in place, the user requests the system to automatically reposition and reshape the objects according to the dynamic grids. The screens both original and reformatted are captured and stored by the system. Fig. 13 is an example from the study. During the study, it can be observed that the users possess some knowledge of functional placement of screen components even though they did not have in-depth knowledge in screen design or graphic design. Participants for this study are staff members of the Faculty of Information Technology at Multimedia University, Malaysia.

Each set of screens both original and their reformatted versions are placed side-by-side in random orders on an intranet online voting system developed for this purpose. Selection is done with radio buttons and submitted at the end of the 10 min session in a computer lab. Thirty information technology students (18 males, 12 females) of Multimedia University participated in this evaluation. The empirical study yielded an average of 67.86% selecting the system-reformatted screens over user proposed screens. The percentage of selection of individual screen is shown in Fig. 14. The results suggest that screens reformatted by the system are generally better than a non-structured approach without dynamic symmetry grids. However, by comparing the results of the empirical studies between previous evaluations with manually reformatted screens (73.23%) and the current study, the average of the latter is lower by a difference of 6.64%. This may suggest that the former approach has a better control of the layouts due to the fine ability of human perception in laying out screen elements in a balance and orderly way. Nevertheless, the participants did not fail to notice the visually pleasing layout suggested by the grids.

4.2. Experiment two: interactive approach

The second study compares user preferences between the interactive object grid layouts of DSGS and layouts suggested by users with only the base grid as a guide. Three other users from the same department volunteered in this study. The individuals first worked with three different types of screens. The layouts are arranged by users according to their preferences and later stored as an image file by the system when they are satisfied. Following this, the system reads the sizes and positions of the screen elements and generates object grids based on the information. Users then attempted a second design by interacting with the object grids through the scale, reshape, and move function. The second layout is stored and the two screens placed in the online voting system for comparison by viewers. Participants were asked to select the most pleasing layout. Twenty-five students (14 males, 11 females) participated in this study, which yielded positive result with an average of 73.33% preferring the second layout over the first. This may suggest two things; firstly, full conformance to dynamic symmetry principles is generally viewed more positively than designing without DSGS assistance. Secondly, the result of this study as compared to the result (73.23%) with previous manual attempts at

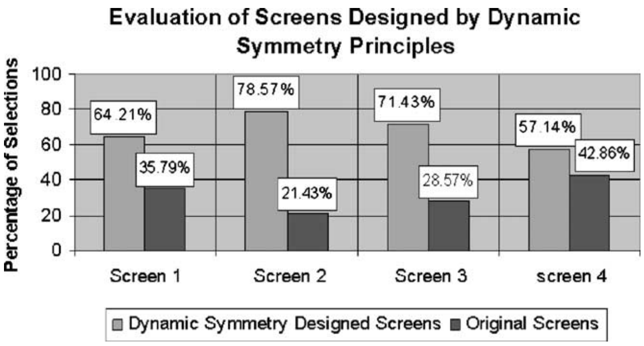

Fig. 14. Evaluation of screens designed by the system.

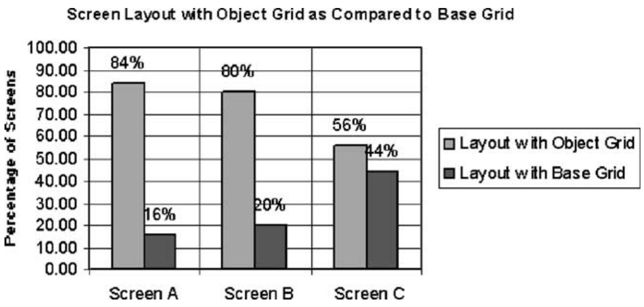

Fig. 15. User preference comparison of object grid and base grid layouts.

dynamic symmetry design is slightly higher, showing that the grid-generating algorithm operates in much the same way as manual dynamic symmetry design. The result is shown in the graph in Fig. 15.

In Screen A (Fig. 16), 84% of the viewers selected the object grid design (b) compared to the original screen (a). The composition of the object grid layout is seen in (c); each object belonged to the same theme. The title has eight vertically positioned squares plus nine other squares placed horizontally. The map has two $\sqrt{5}$ placed vertically end-to-end plus a vertical ϕ^2. The picture to the right is composed of a vertical ϕ plus a vertical $\sqrt{5}$. The first button is composed of a $\sqrt{\phi}$ plus three squares and the second is a double ϕ rectangle.

In Screen B (Fig. 17), 80% of the participants selected the fully dynamic symmetry compliant layout (b) compared to the non-dynamic symmetry compliant layout (a). Fig. 17(c) shows the dynamic symmetry composition. The picture on the left has a vertical double square plus a vertical $\sqrt{\phi}$. The picture at the centre is a double ϕ^2 plus a $\sqrt{\phi}$. The picture to the right is a full $\sqrt{\phi}$ rectangle. The button titled 'Gallery' has two $\sqrt{5}$ rectangles stacked on top of one another plus another horizontally placed $\sqrt{5}$ rectangle. The button at the lower right corner is composed of four $\sqrt{5}$ plus four squares.

Screen C (Fig. 18) has relatively lower selections compared to Screens A and B. The reason for the variation may be due to the misalignment of the two major objects and the placement of the buttons at the lower right corner of the screen (b), leaving an empty gap in between the pictures and the buttons. The characteristic of the dynamic symmetry screen is as follows; the menu bar has vertical double squares plus eleven squares, forming an extended rectangle. The left picture is composed of four horizontal ϕ^2 rectangles placed on top of one another plus a $\sqrt{\phi}$ rectangle. The picture on the right is composed of a vertical double squares plus a vertical 5. The buttons at the bottom-right corner of the screen has four ϕ rectangles plus a ϕ^2 and a square.

In the two empirical studies conducted, viewers' perception of the aesthetics of screens designed using dynamic symmetry grids was clearly better than their non-compliant counterparts. The variation of the ratio is larger for experiment two than experiment one is due to our fine human ability and perceptual judgements in placing objects in an orderly fashion. In these experiments, it is shown that there is a certain appeal in the layout produced by what L.B. Alberti refers to as 'the law of the non-mixing of proportions or themes in a plane composition'. According to Ching [30], 'Proportioning systems…can visually unify the multiplicity of elements in an architectural design by having all of its parts belonging to the same family of proportions.' Layouts arranged according

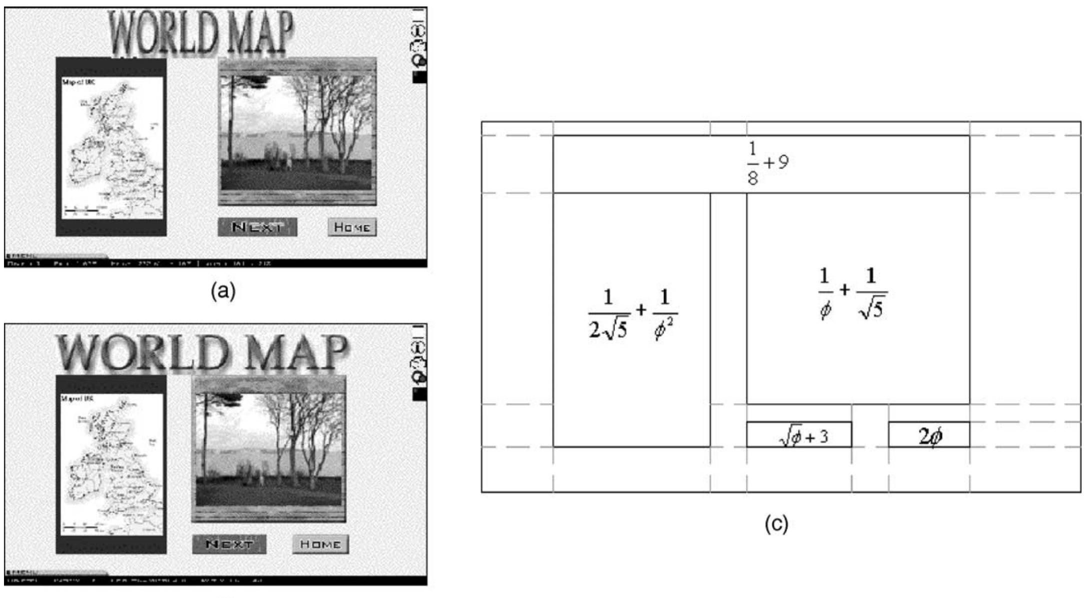

Fig. 16. Screen A—screen with maps. (a) Original screen. (b) Reformatted screen. (c) Reformatted screen analysis.

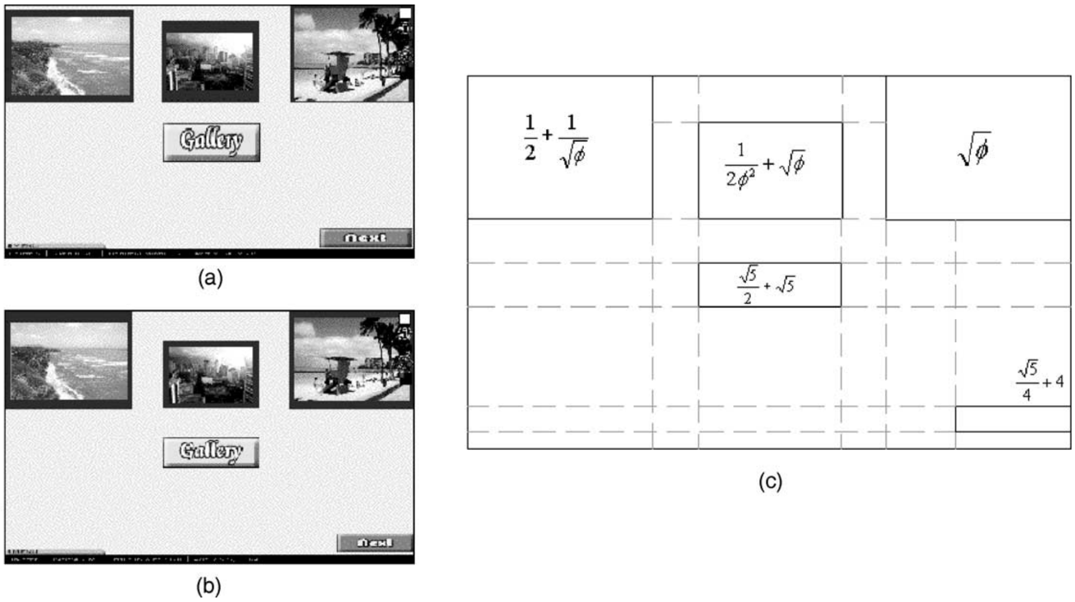

Fig. 17. Screen B—screen with paintings. (a) Original screen. (b) Reformatted screen. (c) Reformatted screen analysis.

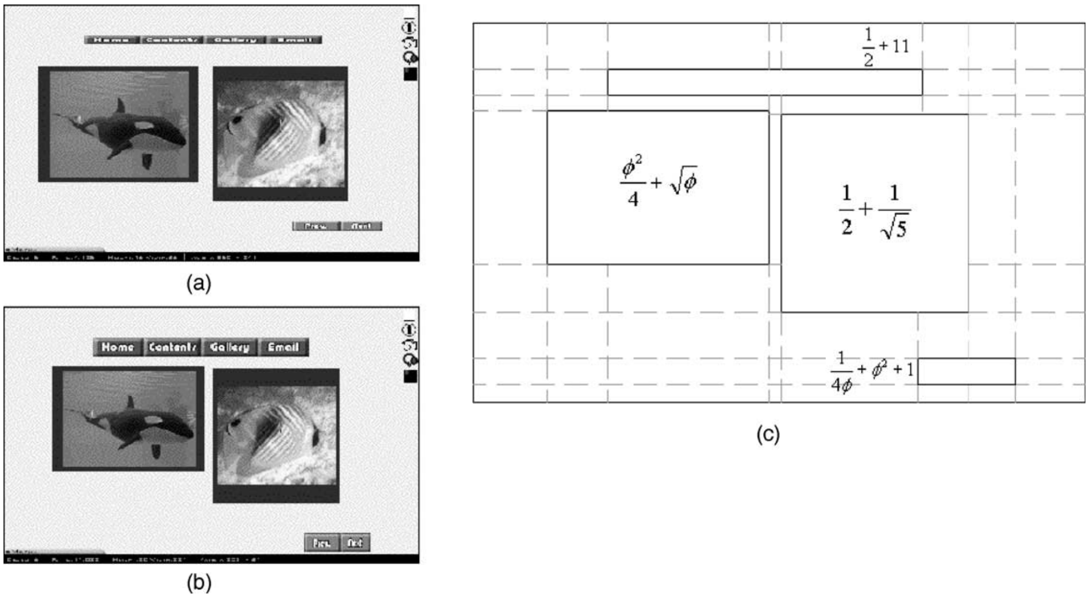

Fig. 18. Screen C—screen with marine life. (a) Original screen. (b) Reformatted screen. (c) Reformatted screen analysis.

to this principle create a sense of order among the elements in a visual construction.

5. Conclusion

DSGS is based on the technique discovered by Hambidge, and focuses on the presentation components of the user interface design problem. The above discussions describe its automated and interactive features. Observation of users during the study on the automated feature compared to the interactive feature of the DSGS showed that the fine ability of human perception in laying out screen elements generates relatively better layouts. In future work, both features of the system can be improved by introducing screen design guidelines such as those proposed by Ngo [9,31]. The research aims to automate the design process as much as possible; by integrating additional design principles coupled with human experimentation such as usability testing of the system, finer layout control during design time can be achieved. Such guidelines should considerably decrease human effort and assist designers in better screen design.

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