Automatic Layout Algorithm for Graphic Language in Visual Communication Design

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***Abstract*—As computer technology advances, people's capacity for visual perception grows better, and the demands placed on computerized layouts progressively rise. The simple style of graphics is no longer the only option for computer figure video creation; instead, there is a greater tendency to visually represent the effect and improve the aesthetics and expressiveness of visuals and images. Graphic language uses visual components, including shapes, colors, typographies, images, and icons, in a visual communication context to express messages, ideas, and emotions. Graphics language encounters greater chances and obstacles against the backdrop of this information era. Consequently, it is crucial to convert data into graphics language. Visual communication is evolving in some potential directions with the advancement of technological advances and cultural convergence. The graphic language has its distinct visual meaning, and each person's visual experience is extremely diverse and exists in life with various visual elements in different layouts. A hybridized Grid and Content-based Automatic Layout (HGC-AL) algorithm for graphic language in Visual Communication Design (VCD) has been developed to produce visually balanced layouts and establish a structured system for arranging content elements. The content-based layout uses design constraints for better alignment and avoids conflict loss. The hierarchical arrangement of graphic elements in a grid layout analyzes the types of visual elements like image, text, and color. Finally, graphic language enhances the visual score and gives flexibility by allowing changes and modifications within the grid layout. Following the design requirements change, the responsive fluid grid supports various graphical content, sizes, and alignments. Thus, compared with existing layout algorithms, the proposed algorithm is validated with metrics like Intersection of Union (IoU), alignment accuracy, content coverage ratio, visual score, scalability ratio, and overall layout quality.**

Keywords—Graphic language; visual communication design; layout algorithm; design elements; grid layout; content layout

I. Introduction

Generally, graphical languages [1] outperform plain languages in features and embody brevity, openness, simplicity, and ease of understanding. That is unaffected by geographical or cultural disparities and allows for vast discussions and inventions across the platform. Visual language [2] is crucial for comprehending the natural environment and human culture, particularly in an era with many visual elements. Visual examination of relational data is essential in most practical analytics applications. The automatic arrangement is a crucial prerequisite for such information to be displayed visually well. Visual communication [3] design is a proactive behavior in the graphic form used to spread specific ideas. Most portions rely on perception and are symbolized by two-dimensional pictures, such as those seen in electronic devices, typesetting, artwork, logos, and graphic layouts [4].

The ability of visual technologies for communication to measure information quickly and in real-time has led to its widespread application in many fields in recent years [5]. Related to this, Zhao [6] investigated and examined the visual alignment of the graphic language in the layout of animated visual guiding technology and incorporated alongside orientation within the film's animation design to make the animation design more in line with recent times. Designers need to be aware of cultural considerations and ensure that graphics are understandable to various people. Liu [7] utilized various cutting-edge science and technology techniques, such as VCD, which is necessary when creating interactive animation special effects to increase the view of VCD success while achieving outstanding knowledge dissemination impacts. This article initially introduced the technology for visual communication design and special animation design. In research [8], color, space forming, and graphical-text conformance, Organizations must strengthen commercial exhibits while laying out, innovating, and reconstructing these three stages of brand design. In visual design, striking the correct balance between computerized analysis and human input is critical. Lu and Huang [9] tried to improve the visual communication of artificial intelligence in the recognition and assessment of graphic design language. With the help of significant targeted location recognition and sentiment categorization using a weighted loss convolutional neural network, it focused on enhancing segmentation of image accuracy and assessing emotions depicted in graphics design. The qualities of a graphic language are: intuitive, vivid, symbolic, and aesthetic. A single graphic language, however, has not produced superior outcomes. Hence, Tao [10] examined the impact of graphic language auto layout on the design of visual communication and comprehended the method of graphic language auto layout to support the development of visual communication. Designers must optimize the layout because the intro is essential in addition to the logo and the best placement of associated components, such as the subject matter. With the help of contrast, proportion, white space, and other elements, the formally established aesthetic rule of layout reflects an abstract generalization of the aesthetic rule of design layout. Due to the existing constraints of artificial intelligence technology, a matching framework based on the formal aesthetic law of layout is a more sophisticated abstracted matching paradigm that necessitates parametric by the aesthetically pleasing law [11]. Visualizing relational information in visual applications provided a fast compound graph with the ability to support user-specified positioning limitations and different kinds of classifications based on previous compound spring embedding technology and best for interactive applications by combining quality layouts and spectral graph velocity. It is crucial to consider the algorithm's capability to manage various user requirements and guarantee correct enforcement [12]. In that point, to deliver various information to users, the long-known symbols supply the fundamental requirements for cutting-edge, interdisciplinary research. In VCD, a particular graphic pattern is frequently made up of just one component, and depending on how it is assembled and used, it can effectively communicate various messages to various people [13]. The messages may involve graphics and pictures used while creating advertisements, poster designs, websites, and logos, particularly in commercial photography. Designers can successfully include product features using hand-drawn techniques, graphics, and picture software, increasing people's appeal [14]. Cui et al. [15] introduced a framework for automatically producing infographics, a subset of graphic language, providing evidence suggesting that it converts a natural language expression on a piece of appropriate information into a collection of expert infographics with different layouts, colors, designs, and options that ordinary people may choose or modify according to their individual choices. However, it can only deal with a limited collection of information, bad icon matching with small font sizes, and arises ambiguity problems. Graphic language plays a relatively minor part in information transmission due to its relative lack of precision, making it difficult to pinpoint information precisely. To avoid this, Wu and Fang [16] suggested a visual communication system based on the hyperspectral processing of images using entropy control stability with good visual communication effects. They can successfully increase the visual communication design effect. Existing methods have looked into using a force simulation and proxy geometry to simplify handling collisions for irregular forms. These specialized force-directed layouts are frequently unstable and necessitate additional constraints to function correctly. Kristiansen et al. [17] described a method for locating central components in a unique grid layout to provide equivalent attractive forces to address these deficiencies. Dayama et al. [18] proposed an integer programming method for interactive layout transfer, where the layout of a source design is automatically transferred using a chosen reference pattern layout while adhering to applicable rules. The source design is an initial rough working draught converted into a rough draught into the final objective layout using a reference pattern. The major objective of the study is:

- The aesthetics and visual attractiveness score of graphic language layouts are enhanced by using the HGC-AL algorithm.
- Apply design constraints for evaluating alignment accuracy, prevent conflict, and effectively design the layout using visual graphics elements.
- Provide a visual balance score by maintaining the hierarchy of elements with their relative importance and update the design changes using responsive fluid grid supports.
- Evaluate the proposed approach using performance metrics like IoU, content coverage ratio, alignment accuracy, visual score, scalability ratio, and overall layout quality.

The remainder of this investigation is organized as follows: Section II details the prior work on visual and graphics language-related layout implementations. Section III details the data source description and proposes the implementation of HGC-AL using various graphic languages and visual elements for effective communication design. Section IV presents the comparative analysis. Section V discusses the results. Section VI concludes the work with limitations of the current study and future work.

II. Prior Work

Zhou et al. [19] proposed a Composition-aware Graphic Layout integrated with a Deep Generative Adversarial Network (CaGL-DGAN) model with an Adam optimizer used to create layouts based on the overall and spatial visual information of input images. A novel domain alignment module was created to close the mismatch between the test inputs without using masks and the inputs used for training with the hint masks. The evaluated metrics are user satisfaction, visual balance, overlapping and graphical readability with root mean square values of x and y dimensions of the text elements using the poster layout design dataset with visual text variation of 0.026 difference with a lack of focus in color base.

Yu [20] elaborated a parallel selection logo to explain the parallel procedure and selection procedure for graphic languages in VCD and realizes the automatic layout of graphical languages using the parallel selection process. Syntax description based on rules and semantic description based on abstract state machines describes visual languages. The ant colony algorithm gets the graphics' demonstrated spot in VCD. The fixed value approach utilized for figuring out the showcase size of the buffer image takes the least layout land optimum surface used as the goal. Results demonstrated that the favorable scheduling impact increased focus and satisfaction.

Wang [21] suggested an algorithm for automatically arranging graphic language in VCD with the Ant Colony (AC) algorithm to get the most effective display location of the images in VCD. The Fixed Value Method (FVM) for estimating the display dimensions of the buffer graphic takes a minimal amount of layout and the maximum surface utilization as the function's objective. Graphic language can be described using syntactic analysis according to rules and semantics. Its application in real-time or resource constraints may consume greater time for processing and demand for resources.

Ma [22] developed a graphics language-based automatic scheduling technique using the Allocation of Resources State (ARS) in automated planning research. Both service management based on port resource conservation of an optical network centered on a multimode and an optical panel allocation of resources is proposed. Focussed on the application and described the dynamic layout's design concepts, methodologies, and shapes.

Wang and Li [23] suggested an automatic structure of graphics language in VCD that successfully resolves the conflict between textural capacity for storage and realism and accomplishes real-time deconstruction and visualization using programmable graphical processors. The technique automatically inserts every element of the code database throughout the compression and coding of the image. The results showed higher satisfaction; it must be tested and validated using various design scenarios not discussed in this study to ensure the algorithm's dependability and adaptability.

Sun and Mattek [24] researched Network VCD is familiar with the design thinking processes for visual information communication and has a wide range of expressive and communicative options. The algorithm of graphic language automatic arrangement in Nvcd is also researched to determine the ideal size and position in NVCD for graphic arrangement. The experimental results showed that the design of graphics makes up 27% of the total, next to film and television design (21%), advertising design (19%), typeface design (14%), and logo design (9%). However, not every user can utilize digital platforms or comprehend nuanced visual cues.

Gong and Fang [25] built a framework for automatic layout optimization called Faster-R-CNN to identify and extract an essential element from posters. It achieves recognition and placement of the format's elements by learning and categorizing the elements using RPN. The main focus is to learn the selected basic format template with the poster case format. The skeletal labeling of the layout's elements is the primary basis for classifying those elements. This framework produced a detection rate of 95% and satisfied the visual communication needs of public cultural signs. The layout is optimized while ensuring that cultural logos adhere to the rules of visual communication and exceed the satisfaction ratio above 70% using the three-division method. It emphasizes the categorized layout's core body and numerous text sections by Soto and Yoo [26]. The exact location of each component can be determined and located once the labeling of the layout elements is complete. The approach makes it possible to learn the target case's layout and finish learning the Layout migration.

Tabata et al. [27] developed a system for automatically generating layouts that combine i) random generation, a set of minimal condition rules, and ii) an assessment of adherence to the intended design aesthetic. This technique makes it feasible to produce numerous innovative layouts while maintaining the original design aesthetic. When text or images add information to layouts, an appropriate layout that considers content and design is automatically developed. A learning-to-rank predictor evaluates the work's look, design, structure, and content; the top ratings are then given to the user. Users can significantly increase layout development and editing efficiency. It could take a lot of time and computation to generate a lot of layout candidates.

The automatic layout procedure performed by an a priori designing approach still needs human input. Thus, Huo and Wang [28] provided an Artificial Intelligence-based (AI) method for designing poster layouts. A Learner and a Generato r (L-G) are both components of the layout construction process. First, the learner generated the initial templates for various composition scenarios using the spatial transformation system. The generator optimizes the first template to create many optimum templates, relying on the LeNet architecture utilizing the golden ratio and the trilateration technique. Due to the template's structure and framing fashion, the starting points are kept in an archive of matching templates. The lack of annotated training datasets focusing on poster layouts alone might have an impact.

Zhang [29] enhanced the two-way long- and short-memory model of a neural network to identify the poster using graphic language and investigated the mathematical modeling of graphic language in VCD better, thereby increasing the accuracy of the computer's ability as 0.843% and utilized the minimal time for the recognition process. Hence, the classification efficiency here is 1692.5 s; the identified research gaps in this study are network representation ability is insufficient and the network correctness is not elevated.

Xu and Shi [30] created a collection of automatically suggested visual type annotation systems that primarily process data and look for big data in the system using user field information. The user can then be advised of the best visual mark to use so that the information can be presented to them as graphics. The attributes used for automatic recommendation are dimension, color, size, shape, label, and tag type. Users can save additional time and effort by having the system recommend the best label style in single and bi-axis types. The major limitation here is no further in-depth examination of the information. Only tag options are recommended to users.

He [31] explored the design process of a visual interface using interactivity and the experience of users to achieve the goal of information transfer by employing interactive information visualization. This article makes recommendations for improving the interactive design of visual communication from the focal points of attention, awareness, and memories by analyzing users' cognitive processes in each stage of visual-based activities. The algorithm's accuracy reaches 0.963%, and user satisfaction is 0.959%, with a faster convergence time. However, this study has drawbacks related to the detailed description of expression and visual aspects of elements.

Kikuchi et al. [32] proposed a framework name Constrained Layout Generation through Optimization (CLO) with unconstrained layout generative adversarial network++ with the latent codes for evaluating the alignment of elements, overlapping issues, and other user-specified relations. The metrics related to the Intersection of Union (IoU), constraint violation, and alignment comparing three publicly available graphic-related datasets, including various visual elements like images, text, icons, logos, etc. The major drawback is issues related to visual quality may occur there may be a need for an extra training period for discriminators.

The review study details the prior work related to the VCD field with graphic language of automatic layout algorithm with fullest satisfaction of user identification ratio and various design scenarios, practical usage, and dynamic designs.

III. Proposed Algorithm

Using graphics and visuals to communicate ideas is known as visual communication design. Four fundamental components are primarily used when producing visual communication effects: graphical style, text structure, graphic hues, and graphic arrangement la layout. Providing visual information and making the viewer attractive are important aspects of layout design. Quantitative design encompasses the development of technological advances in graphics and visuals. It can separate graphic images' color and structure details into separate, quantifiable, and measurable independent pieces. Graphic language includes the principles, procedures, and phrases used in visual design to build coherent and meaningful compositions. Graphical components such as lines, forms, shades, layout, structure, and visual hierarchical arrangement express ideas and produce striking visuals. In the subject of visual communication design, messages are effectively conveyed through the use of images, typography, and layout. It can be applied in some ways, including marketing, advertising, and producing signage or educational materials. To successfully explain the facts or information being shown, visualization frequently uses design ideas from graphic languages, such as the use of a visual hierarchy, color coding, and typographical nature. The fundamental element of visual layouts, such as those for newspapers and magazines, advertisements, cartoons, and internet pages, is layout. A good layout can improve content presentation, direct reader focus, and increase visual appeal. Fig. 1 depicts the implementation of HGC-AL for effective VCD.

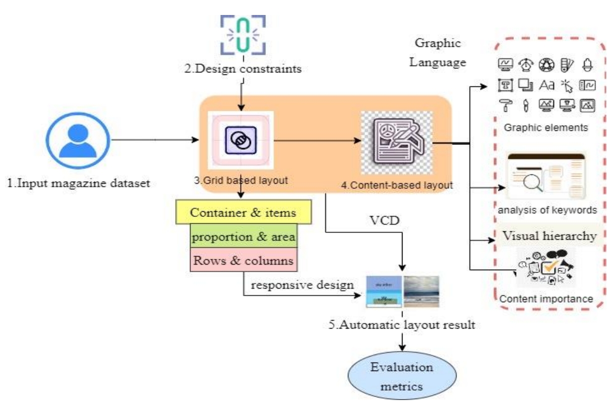

Fig. 1. Implementation of HGC-AL.

The innovative approach combines two fundamental principles - grid-based layout and content-based design - to enhance the efficiency and creativity of graphic language in visual communication. By integrating these two methods, the work offers a comprehensive solution that ensures visual coherence through the use of grids but also allows for dynamic and adaptive layouts based on the presented content. This hybridized approach empowers designers with a versatile toolset to create visually appealing and effective communication materials. Additionally, it addresses the evolving demands of contemporary design, where flexibility and automation are crucial. Overall, this work opens up new possibilities for graphic designers, enriching their creative processes and enabling them to produce more engaging and impactful visual communication designs.

A. Input Magazine Dataset

The magazine dataset includes several categories of graphic elements, including images, text, colors, and other visual components represented in this block as the input information used by the layout algorithm. However, some datasets with semantic segmentation are openly accessible to magazines and academic journals. From Zheng et al. [33], 3 919 pages of magazines from the Internet that cover six common topics, namely fashion, nutrition, headlines, technology, traveling, and weddings, make up the dataset. The six categories total 685, 753, 618, 509, 721, and 633 pages, respectively. The types of graphic language labels to encode the layout of each page to enhance VCD with element categories are Text, Image, Headlines, color, and Background. Pages from various categories display a variety of layouts in terms of the quantity, size, and spatial positioning of page elements. The most commonly used AR of magazines are 4/3; hence the general representation of the layout to be generated may be fixed as the dimension of 60×45. Capture the design aspects: Identify the visual aspects that should be properly integrated into the layout, and graphics could consist of text blocks, pictures, logos, icons, and other graphical elements. Each element should have the appropriate qualities, such as dimension, position, alignment, and visual order. Based on this dataset, the layout of the graphic visual elements needs to be arranged automatically by following the design constraints given in subsequent content and applying HGC-AL.

B. Design Constraints for Various Attributes

Before applying the layout algorithm, the basic design constraints must be fixed to enhance the visual appeal, usefulness, and user experience of the graphical layout. The goal of adding design qualities into a layout algorithm utilizing graphic language is applied in the collected dataset to generate a layout design. The design constraints are used to direct the layout-generating process represented by this block with criteria for alignment, overlapping, size, location and spacing, proportions, and other design principles. Design the guidelines that must be followed throughout the layout-generating process, including element associations or alignment, closeness, and spacing constraints. These design constraints are used for element coordination, conflict avoidance, or user-specified interaction. To identify the conflict loss between elements pairs in the layout composition.

$$Cl_{loss} = \sum_{i=1}^{Z} \sum_{j!=i} \frac{e_i \cap e_j}{e_i} \quad (1)$$

As mentioned in Eq. (1), $e_i \cap e_j$ represents the intersection or overlapping region of two elements i and j. Element alignment is adopted for the sample rectangle shape with the two basic alignment principles, edge alignment and center alignment, to avoid this conflict loss problem. A common strategy is edge alignment, which involves aligning parts with an outer boundary that intuitively matches their exterior edges. The function provides the orientation and positional information for the list elements to create acceptable visual groups. The two elements' size and shape are considered when choosing the alignment. A visual hierarchy throughout the layout structure is established using alignment. You can clearly distinguish between different subsections or stages in importance by aligning text elements. Aligned text enhances the design's aesthetics and attractiveness with hierarchy and increases the visual score. An automatic layout plan is more aesthetically pleasing when balanced alignment conveys an emotion of order and balance.

Pseudocode-Rectangular type element alignment for enhancing the visual score

```
Input: rectangular shape as rect (length as l, height as h, width as w), top, left.
Output: element alignment as el
if rect.l<3 then
  Compare sim(w, h)
  if (max (w)> max (h), then
    el⟵el_left
    update longer w on top
  else
      el⟵el_top
      update longer h on left
end if
else
  rect ⟵bgRect (rect)
   if rect.h>rect.w then
      el⟵el_left
   else
      el⟵el_top
    end if
end if
```

1) Intersection over Union (IoU): IoU can be used to evaluate how well the projected arrangement and the actual layout agree or line up. Locate the area where the expected layout and the actual arrangement overlap, which can be achieved by locating the areas or components shared by the two layouts. Subtract the union area from the intersection area, and the calculated value indicates the degree of agreement or overlap between the expected and actual layouts.

IoU value ranges from 0 to 1, where 0 means no overlap and 1 means perfection in the overlap. For the intersection area of a design element, the notation $e_i \cap e_j$ and $e_i \cup e_j$ the intersection and union of measures can be calculated using Eqs. (2) and (3).

$$IoU_{VCD} = \frac{e_i \cap e_j}{e_i \cup e_j} \tag{2}$$

$$e_i \cap e_j = (e_{i1}^I - e_{i0}^I) * (e_{j1}^I - e_{j0}^I) \tag{3}$$

Combining the two boxes' areas and deducting them at their junction allows one to find the union area of two boxes using Eq. (4) and Eq. (5).

$$e_i = (e_{i1}^i - e_{i0}^i) * (e_{j1}^i - e_{j0}^i) \tag{4}$$

$$e_j = (e_{i1}^j - e_{i0}^j) * (e_{j1}^j - e_{j0}^j) \tag{5}$$

In visual communication design, an image's aspect ratio is useful since it offers important details about the proportions and shape of the image in three variants: portrait, landscape, and square. Suppose an image element's aspect ratio is greater than the picture's. In that case, the image is scaled to match the image element's width while maintaining its aspect ratio, and then the centers of the two are aligned. Then align the images along the vertical axis by the center, top, or bottom boundary because the scaled image is taller than the image element using Eq. (6).

$$AR = w/h \tag{6}$$

w indicates the width of an image, h represents a height of an image.

The design attributes are included with graphic language and consider i) color as the initial graphic language representation to generate an automatic grid layout based on the input contents. The color scheme is carefully chosen to produce a unified and aesthetically pleasing appearance. Depending on the branding and content of the magazine, it might use both vivid and subdued colors. The appropriate application of color may generate feelings, convey meaning, and have a strong visual impression. The mood, accessibility, and overall aesthetic elegance of a design can all be impacted by color choices. Readability can be improved by using lighter backgrounds with darker text or the opposite. A focal point or important information can be highlighted with a strong, brilliant color to grab and direct the reader's attention. The layout automatically generates the results according to the given visual element using the "adjustColorPalatte ()" method in design constraints of the color attribute

2) Size and location constraints: Size and location constraints are derived from Kikuchi et al. [32] to generate an effective layout. Three categories must be considered for the size element constraint: small, large, and equal. If a user specifies that j^{th} element has to be larger than the i^{th} element, the sum of cost functions of larger relation is calculated using Eq. (7) as:

$$S_{\mathrm{lg}(e_i,e_j)} = \max((1+\gamma)A(e_i) - A(e_j), 0) \tag{7}$$

Where $A(\cdot)$ represents the function that the occupied area of the given bounding box and γ is a tolerating variable shared between the relations of the size. Likewise, Eq. (8) calculates the location constraint with five variables above, left, right, bottom, and overlap. If an element e_i has to be present right of an element e_j then, the right location's cost-related function is given.

$$L_{\mathrm{r}(e_i,e_j)} = \max(y_l(e_j) - y_r(e_i), 0) \tag{8}$$

Where $y_l(\cdot)$ and $y_j(\cdot)$ denotes a function that returns a considered bounding box's left and right coordinates.

Based on these design constraints for aligning text, image, size, location, and color arrangements, IoU analysis inside a layout with correct columns and width spans in the container must follow the grid layout design.

C. Grid-based Layout

This block represents the grid-based layout algorithm, creating a grid structure with well-defined columns and rows out of the available space. The grid provides a structural framework for organizing and positioning the graphic languages within the layout. Grid-based layouts prioritize structure, responsiveness, and resource optimization, while content-based layouts emphasize every component's importance and enhance the overall user experience. A grid-based layout's main goal is to arrange items methodically and consistently. It strives to align pieces along horizontal and vertical principles to create a visually balanced and well-organized composition. Grids ensure that elements keep a consistent connection to one another and give the structure an aesthetic feeling and harmony. Grid-based layouts are effective in using space, especially when dealing with a lot of content or objects arranged in a grid-like pattern. By placing components in a grid, they may maximize the potential of the space and available reduce unused space, assuring an aesthetically appealing and well-organized design. According to the screen size, the fluid grid's variable content breadth can span the entire edge concerning the graphical language used in the design constraints. Columns in a fluid grid have variable widths, whereas the gutters and side margins are fixed.

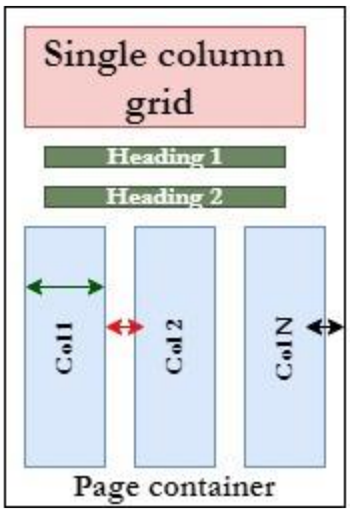

Fig. 2. Basic grid layout design for a magazine.

Create a structure based on grids with a fixed number of rows and columns, as shown in Fig. 2, with several attributes. The red color arrowhead represents the space between column grids in which the areas between the columns are known as gutters aid in dividing the text; the green arrow represents the space within the column surrounded by the page container, adopts the design layout based on the given input type of graphic language to enable the good score of visual communication. Breakpoint refers to a particular range of sizes of screens wherein the layout is re-sized to the available screen size for the optimum layout view. The margin of the layout defines the magazine content and the edge of the screen layout. The grid serves as an outline of the algorithm that gives the layout a dependable sense of alignment and structure of visual elements arranged based on a content-based layout. Here the layout dimension is taken as of width (w) size as 100 cm; hence the number of columns in a grid cell is taken as 12 to calculate the width of each column as $w/no.of\ columns$, then it gives a unit-wise wider area. Similarly, the no. of rows is taken as 3 for this $h/no.of\ rows$ is calculated; hence the resultant value is 15 units high. Hence, the resultant grid sample will be square with equal width and height space. This grid layout separates the pages into sections like rows and columns for varying magazine trends arrangement to enhance the design principle of graphic language. Then follow the alignment rules to create visual order and balance with the help of proximities like size and location for enhancing the reader's understanding and satisfaction.

The layout design is aligned with the proper graphic language with its importance related to contents for enabling visual communication and delivering the message with good visual score and readability. The content-based layout needs to be followed, which is given in the subsequent section.

D. Content-based Layout

The content-based layout algorithm is represented by this block in which each graphic element's attributes and significance are examined, including its visual impact and relationship importance to other elements, as shown in Fig. 3. It uses this data to decide where elements should be placed in the grid and how they should be arranged. Here the importance of keywords to display the content about the given category based on term frequency-inverse document frequency is given below:

1) Keyword/text importance: The term frequency-inverse document frequency $(tf - idocf)$ method counts the number of words in a collection of documents and calculates a score for every word to reflect its weight in the corpus and document. The term frequency calculates the word frequency in the text and is heavily dependent on the size of the content inside the document as well as generality. Since TF is specific about every document and word, the term t denotes the term or word doc denotes the document where a group of words occurred. N denotes the corpus count referring to the total document set. DF is the number of times a term appears in the document set N and identifies a document's significance within the corpus as a whole. DF is the number of times the phrase t appears in the information set N. In other words, DF represents the number of documents containing the word. IDF, which quantifies the informativeness of a term t, is the inverse of document frequency.

$$tf(t, doc) = count\ of\ t\ in\ doc/no.of\ words\ in\ doc \quad (9)$$

$$idocf(t) = \log\left(\frac{N}{(docf+1)}\right) \quad (10)$$

$$tf - idocf = (count\ of\ t\ in\ doc/no.of\ words\ in\ doc) * idocf(t) \quad (11)$$

From these above Eq. (9)-(11), the relative weightage of a word can be calculated where the repeatedly occurring words like stop-words in a magazine have a very low $idocf$ score. Depending on the high TF-IDF evaluations, determine the keywords or significant terms and allocate sizes to text elements according to their significance or relevancy. For example, greater sizes can be given to those with higher TF-IDF values to visually emphasize the importance of text elements within the layout. Consider utilizing bigger font sizes, bold or italics formatting, or distinctive colors to draw attention to keywords within the content. The content makes the key phrases more noticeable to readers and stimulates interaction with the destination knowledge.

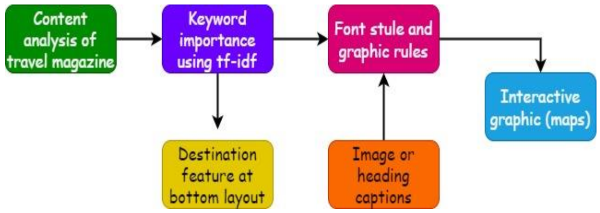

Fig. 3. Content-based layout of graphic language for traveling magazine.

E. Automatic Layout Representation

This block depicts the algorithm's final result, a created layout that blends the concepts of grid-based and content-based layouts. According to the limitations of the design and aesthetic considerations, it displays the graphic elements' ideal arrangement.

The font size for the text and text-over-image elements is fixed to make it easier to see the generated layouts. In contrast, the font size for the headline and headline-over-image portions is set to a minimum of three times larger and fluctuates depending on the size of the corresponding regions. According to the design and intended amount of emphasis, the font size commonly varies between 24 pt to 72 pt or greater. Change the font size based on the image proportions and the headlines' effect on readers. The grid structure adjusts and scales by implementing responsive fluid grids following the available screen size. The technique gives grid columns proportional widths to alter dynamically rather than set column widths. Instead of using fixed pixel values, content items within the grid are placed using relative measurements. The technique of arranging items to demonstrate their relative importance can be called visual hierarchy. Designers organize visual elements, such as menus, images, colors, texts, and symbols, so users can easily comprehend information. Designers modify users' views and direct them towards desired actions by arranging things logically and strategically. It ensures the best possible use of the available space by allowing objects to scale and reposition themselves according to the screen size.

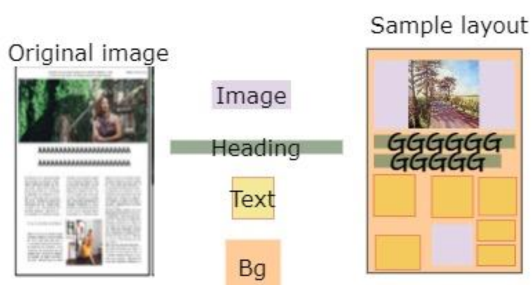

Fig. 4. Layout representation of graphic languages using visual elements like image, text, and background.

As shown in Fig. 4, the input image is taken from a magazine type called traveling, where the graphic language contains the four partitions generated to design the grid-based layout, and contents are aligned with separate columns and rows based on the width and height of the layout dimension area. Initially, the background is identified from the color palette function extracted from the color design attribute rules. The image is identified with the element pair of i, and j coordinates to find the dimension with overlap functions, size, and location proximities. Then the heading category is aligned with boldface dark font. The text is aligned based on the left and right alignment rules without overlapping regions.

IV. Experimental Analysis

The proposed algorithm is compared with four existing approaches, CaGL-DGAN [19], AC-FVM [21], AI-L-G [28], and CLO [32], using various metrics like IoU analysis, alignment accuracy, content coverage ratio, visual balance score, scalability ratio, and overall quality score.

A. IoU Analysis

Whenever the IoU number is high, two separate boundaries have a lot of overlap or similarities. IoU is frequently used to assess the precision of anticipated bounding boxes compared to ground truth indications in tasks like identifying visual elements and image recognition using Eq. (2).

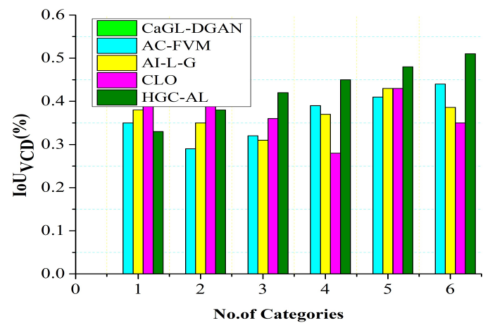

Fig. 5. Comparison analysis of IoU values.

Fig. 5 depicts the IoU analysis of image overlapping in six categories of domains like fashion, nutrition, headlines, technology, and traveling wedding. Typically, IoU is stated as a number between 0 and 1, with 0 denoting no overlap and 1 denoting a perfect match or total overlapping between the layouts. IoU can be used by designers as an input system to hone and enhance layout algorithms. Designers can pinpoint areas for improvement and modify the algorithm variables or limitations by examining the IoU ratings for several design iterations.

B. Alignment-Accuracy Measure

Using design constraints like alignment rules for graphic elements in VCD, including text or image alignment. Suppose the aligned text matches the design constraints and follows the pseudocode rules of left, right, bottom, and height categories. If the alignment is text element need to store in the fashion layout with the corresponding keywords extracted using the frequency of occurrences and its relevant scores for the proximities of size and location constraints based on the obtained score, the alignment accuracy is evaluated.

$$Alignment\ Accuracy(\%) = \frac{(score1*wt1+score2*wt2+..+scoreZ*wtN)}{(wt1+\cdots..+wtZ)} \quad (12)$$

From Eq. (12), $score$ is calculated from relevant extraction methods like $tf - idocf$ for text, and the score will vary for other visual elements design patterns like traveling, wedding, and technology because each magazine has different visual styles of the alignment procedure. Based on this alignment rule, the accuracy of aligned text has been calculated.

As depicted in Fig. 6, the alignment accuracy increases if the score of the extracted graphic language increases and follows the alignment rules derived from design constraints. The alignment must include the graphical language measure, like the wedding category has a separate theme like the fashion category has a separate theme in the background. Based on this graphic language analysis, the relevant text is separated and aligned based on the score acquired.

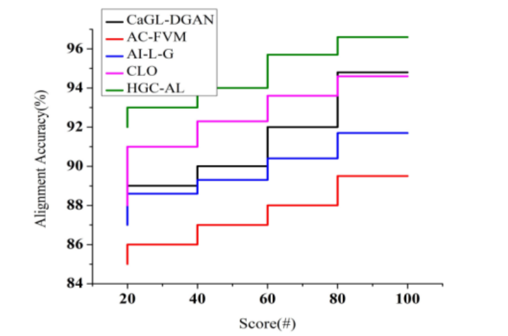

Fig. 6. Calculation of alignment accurateness.

C. Content Coverage Ratio (%)

The CCR determines the entire area that the grid's elements of content occupy, and the content coverage ratio is calculated by adding together the areas of all the content elements and dividing that sum by the grid's overall area. The CCR from Eq. (13) shows how much of the grid layout is taken up by the graphical content elements. A higher CCR indicates greater coverage of the space accessible by the design elements.

$$CCR = (Sum\ of\ content\ element\ areas)/total\ grid\ dimension \quad (13)$$

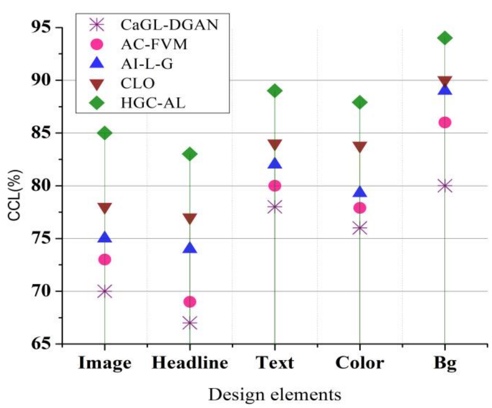

Fig. 7. CCR analysis.

As shown in Fig. 7, CCR analysis results in a comparison between the existing and proposed approach gives the better coverage aspect of design elements in HGC-AL with the additional effort of grid layout usage since this approach provides a better resource utilization related to content by identifying the relevant column and width spaces of each grid cell to reduce the wastage of unused space. In this dataset, the magazine categories are related to several types of fashion, nutrition, and headlines, including graphic design elements like image, text, color, and background aligned with the design constraints.

D. Visual Score Analysis

As shown in Fig. 8, the graph compares the criteria aspects like proportion, text, alignment, color distribution, size, location, and image flow are examples of particular criteria that affect visual balance with various existing and proposed HGC-AL. Design best practices and these requirements should be compatible based on design constraints. For a given layout, assess each criterion separately and give it a score depending on how well it satisfies that criterion. That can be a scale of 1-10 and a subjective rating from layout designers considering the balance attained in visual communication design elements.

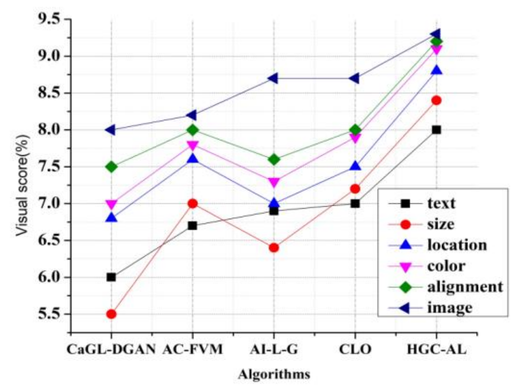

Fig. 8. Visual score comparison.

E. Analysis of Scalability Ratio (%)

An HGC-AL algorithm's scalability may also be affected by N no.of design constraints like conflict loss, content hierarchy, alignment rules, IoU, size, and location constraints are increasingly difficult as the amount of content rises. The algorithm's scalability can have trouble staying consistent and adhering to the rules.

From Eq. (14), the scalability of the proposed algorithm increases as the content count or size increases for six categories of magazines with different contents like image, text, color, headline, and background concerning the design constraints of the graphic language elements. Here α, β, and γ represent the coefficients that denote the relative importance of each design criterion employed in the HGC-AL algorithm.

$$Scalability\ ratio(\%) = \alpha * (content\ count) + \beta * (design\ constraint\ 1) + \cdots + \gamma * (design\ contraint\ N) \quad (14)$$

From Fig. 9, the graph shows the scalability ratio analysis of various algorithms concerning design criteria or constraints and the content count of each magazine category. The proposed algorithm scales well concerning each design constraint as the content count increases. It improves the algorithm's scalability compared to other approaches using the hybridized concept.

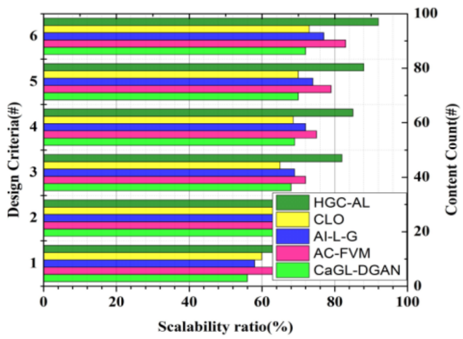

Fig. 9. Scalability ratio analysis.

F. Overall Layout Quality Consideration

The various evaluation criterions used to assess the layout quality are represented on the x-axis. Aspects like aesthetics, unity, content hierarchy, color contrast, accessibility, functionality, and other pertinent design criteria can be included in these considerations. The layout's quality score is shown on the y-axis following the evaluation criteria taken from Zheng et al. [33].

$$O_{lq} = SUM(score(i) * wt(i))/SUM(wt(i)) \quad (15)$$

From Eq. (15), the score (i) represents the score allocated to the current ith evaluation criteria, with $wt(i)$ denoting the weight assigned to the ith evaluation criteria concerning the relative importance of each criterion utilized in this calculation.

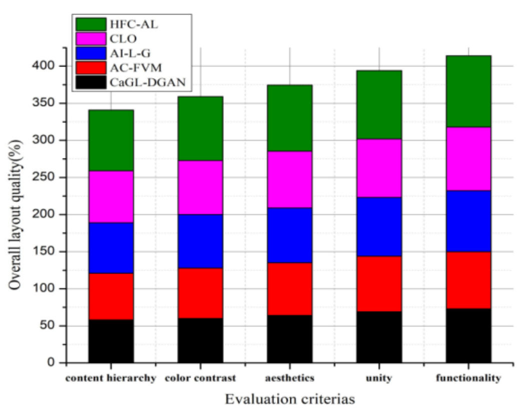

Fig. 10. Overall layout quality analysis for various algorithms.

The score calculated from Fig. 10 shows the total assessment of all design factors considering the relative importance of each parameter that produces the overall layout quality of each algorithm. By calculating this total quality score, the performance and advantages of the proposed HGC-AL technique are proven to have superior and good quality scores compared to other existing approaches.

V. Discussions

The proposed Hybridized Grid and Content-based Automatic Layout algorithm exhibit notable advantages compared to existing methods such as CaGL-DGAN, AC-FVM, AI-L-G, and CLO in visual communication design. Its IoU analysis scores consistently outperform these methods, indicating superior accuracy in replicating desired layouts, which is crucial for maintaining design integrity. Secondly, alignment accuracy is a standout feature, as the algorithm excels in preserving visual coherence and ensuring proper element alignment, surpassing the precision of the existing approaches. Furthermore, the content coverage ratio metric demonstrates the algorithm's proficiency in maximizing information presentation within available space, a critical aspect of effective communication design that it accomplishes more efficiently than its counterparts. The visual balance score consistently ranks higher, showcasing its aptitude for creating aesthetically pleasing designs, a feature that sets it apart in aesthetics. Its excellent scalability ratio underscores its adaptability across various design scales and complexities, making it a practical choice for various design projects. The algorithm's impressive performance across these metrics contributes to a significantly higher overall quality score than the existing methods. This comprehensive superiority positions the Hybridized Grid and Content-based Automatic Layout algorithm as a valuable and versatile tool in the field of visual communication design, offering enhanced accuracy, alignment, content coverage, aesthetics, and scalability for designers seeking to create impactful and visually engaging communication materials.

VI. Conclusion

The creation of images and visuals for computers not only advances computer development but also helps to improve graphic and image design. The study of VCD has changed people's conceptions of life and consumption while introducing them to innovative and personalized visual appraisal activities. For creating visually balanced layouts in Visual Communication Design (VCD), the HGC-AL algorithm offers a dependable and effective solution. The method ensures that graphic elements are placed in the best possible location while considering design limitations and alignment by combining grid-based structure with content-based analysis. It improves the visual score and offers versatility and adaptation to shifting design specifications. Metrics showing the algorithm's performance over competing layout algorithms include the intersection of union (IoU), alignment accuracy, content coverage ratio, visual score, scalability ratio, and overall layout quality. The HGC-AL algorithm improves graphic language and communication in visual design by producing aesthetically appealing and efficient layouts. Thus HGC-AL enables a more efficient design workflow by automatically ordering and placing content items in a grid layout according to established design constraints and techniques. The major limitation of this study involves that if the design constraints of graphical elements are not satisfied, it may affect the quality of the generated layout model. Hence, future work will focus on dynamic updates of the design constraints and the suitable optimization algorithms for attaining effective layout quality.

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