Grenze International Journal of Engineering and Technology, June Issue

Employing Image Processing to Extract the Sudoku Puzzle from an Image and solving it with a Backtracking Algorithm

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***Abstract*— Using the Backtracking Algorithm Solve the unsolved Sudoku. The approach for solving Sudoku puzzles comprises extracting the puzzle from a picture using image processing techniques, and then solving the puzzle using a backtracking algorithm. To detect the circles and digits in the image, the initial part of the procedure entails pre-processing the image using a variety of methods, including adaptive thresholding and the Hough Transform. The circles and digits can be separated from the rest of the image by using these techniques to identify their contour. A pre-trained model is used to recognize the numbers and store them in the appropriate places in the puzzle after the circles and digits have been detected. This model can properly identify the digits even when the image quality is poor or the problem has been captured at an angle because it was trained on a big dataset of photographs of Sudoku puzzles. The method uses a backtracking algorithm to solve the puzzle after the recognized digits have been added to it. This method operates by repeatedly attempting various digit combinations in the puzzle's empty cells, and iterating backwards anytime it comes upon a contradiction. Overall, the technique can extract the puzzle from the image and correctly identify the numbers, enabling it to finish the puzzle rapidly and show the solution.**

***Index Terms*— Full Solved, Half Solved, Sudoku Solver**

I. INTRODUCTION

The Japanese word "Sudoku" is short for the phrase "Suuji wa dokushin ni kagiru", which means "the digits must remain single". It is a very popular problem that develops our ability to think. This well-known puzzle can be solved in a variety of ways. This Sudoku employs the numbers 1 to 9 and has a dimension of 9 rows and 9 columns. The origins of Sudoku can be traced to the Swiss mathematician's game "Latin Squares" from the 18th century, and some of the earliest newspaper crossword puzzles were published in France in 1895. However, Howard Garns, a freelance puzzle creator from Connersville, Indiana, USA, created the modern Sudoku game as we know it today. It was first published in the Dell Pencil Puzzles and Word Games magazine in 1979. Due to the fact that it required putting individual digits into vacant spaces on a 9 × 9 grid, the puzzle was also known as "Number Place." The title "Sudoku" was given to the game when it initially debuted in Japan in 1984. Over 600,000 Sudoku publications are purchased each month in Japan, demonstrating how popular Sudoku remains there. Since crossword puzzles in the Japanese language don't function very well, Sudoku puzzles were much more successful in Japanese society.

Grenze ID: 01.GIJET.10.2.517

This is one of the reasons why Sudoku puzzles are so adored there. The Conway (New Hampshire) Daily Sun was the first American newspaper to print Sudoku puzzles in 2004, and The Times of London started publishing them in 2005. Sudoku has spread over the globe in the last ten years. The inaugural World Sudoku Championship took place in Italy in 2006, and the 2013 edition will take place in Beijing.

A. Rules for Sudoku puzzle

A player simply needs to be able to think logically and be familiar with the numbers from 1 to 9 in order to play Sudoku. The objective of this game is simple: use the numbers from 1 to 9 to fill in and finish the grid. The difficulty comes from the limitations the player must adhere to in order to fill the grid.

Rule 1: The numbers in each row must range from 1 to 9, without repetition. According to this rule, each row of the Sudoku grid must have a single instance of each number from 1 to 9, and no number may occur more than once in a single row.

It is a legitimate row, for instance, if the first row of the Sudoku grid contains the numbers 4, 2, 3, 5, 6, 7, 8, and 1, since it contains all of the numbers from 1 through 9 and no number is repeated. The first row, however, would be invalid if it contained the digits 4, 2, 3, 5, 6, 7, 8, or 9 because the number 9 appears twice.

Rule 2: The numerals 1 through 9 must appear only once in each column. According to this rule, each column of the Sudoku grid must have a single instance of each number from 1 to 9, and no number may occur more than once in a single column.

In the first column of a Sudoku grid, for instance, if the numbers 4, 2, 3, 5, 6, 7, 8, and 1 are present, it is a valid column because it has all of the numbers 1 through 9 and there are no repeated numbers. The first column would be invalid if the digits 4, 2, 3, 5, 6, 7, 8, or 9 were present because the number 9 appears twice.

Rule 3: Each block (mini-grid) may only have one occurrence of each numeral. According to this rule, each 3x3 area of the Sudoku grid, sometimes referred to as a "mini-grid," must contain exactly one of each number from 1 to 9, and no number may occur more than once in a single mini-grid.

For instance, if the Sudoku grid's top-left mini-grid contains the numbers 4, 2, 3, 5, 6, 7, 8, and 1, it is a valid mini-grid since it contains all of the numbers 1 through 9 without any repetitions. The top-left mini-grid, however, would be invalid if it contained the digits 4, 2, 3, 5, 6, 7, 8, or 9 because those numbers appear twice.

Rule 4: states that each row, column, and mini-grid must add up to 45. According to this rule, each row, column, and mini-grid in the Sudoku grid must add up to 45. This is due to the fact that the sum of the digits 1 through 9 is 45 (1 + 2 + 3 + 4+5 + 6 + 7 + 8 + 9 = 45).

For instance, the top row of a Sudoku grid that has the numbers 4, 2, 3, 5, 6, 7, 8, and 1 is a valid row because the sum of the row is 45. On the other hand, if the top row had the digits 4, 2, 3, 5, 6, 7, 8, 9, and 0, the row's sum would be 39, and it would be.

II. METHODOLOGY

The system receives an image of a Sudoku problem that has been partially or completely solved, with the entered numbers circled. The Sudoku board in the image is located by the system using image processing methods. This would entail trimming the photograph to emphasize the board and possibly using filters to make the board and circles more visible. To find the circles in the image, the system employs image processing methods. In order to do this, circular forms must be detected using filters, and the circles may then be more precisely identified using edge detection or other methods. After locating the circles, the algorithm makes the circles thicker to conceal the numbers inside of them. This can entail making the circles' line width wider or giving them a solid color fill. The system develops a model for finding the numbers in pictures of the circled numbers using deep learning techniques. In order to do this, the model must be trained on a dataset containing pictures of circled numbers with labels identifying the numbers they contain. To identify the numbers on the Sudoku board, the system use the trained model. A backtracking algorithm is used by the system to resolve the Sudoku puzzle. A backtracking algorithm is a kind of search algorithm that seeks to solve a problem by methodically investigating all viable solutions and eliminating those that do not. The technology shows the user the finished Sudoku puzzle after it has been solved. This may entail showing a fresh image of the finished Sudoku problem or superimposing the solved numbers on top of the original image of the Sudoku board.

A. STEPS

Step 1: The user uploads an image of a partially or fully completed Sudoku puzzle with the entered number marked in the solution.

Step 2: Using the proper processing, the system locates the Sudoku board in the image.

Step 3: The system then locates the circle in the Sudoku.
Step 4: After locating the circle, the system thickens it to cover the number.
Step 5: Utilizing Deep Learning in Make a model for counting objects in images.
Step 6: Determine whether the number is in a Sudoku.
Step 7: Using the Backtracking Algorithm Solve the Sudoku
Step 8: Show the completed Sudoku puzzle.

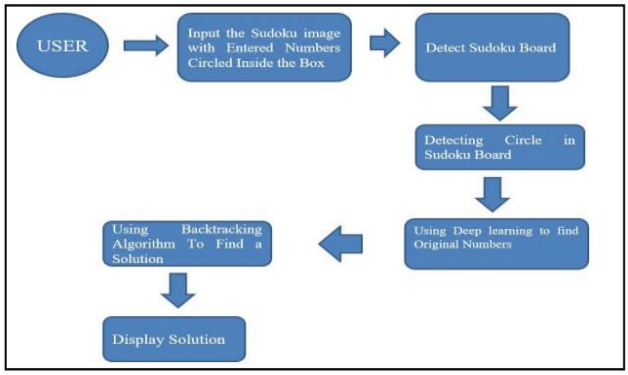

Fig.2.1 Flow diagram

III. TECHNIQUE AND RESULT

The procedure can be largely broken down into the following steps:
In order to find a solution, the user circled the number input and uploaded the image to the system after attempting to solve the Sudoku but failing or doing it wrong.

Fig. 3.1 Preprocessing Image

Image Pre-Processing Preparing the picture data for subsequent analysis or processing is a frequent step in image processing and computer vision activities. In order to eliminate extra brightness, the system uses gray scaling to detect the uploaded image.

Fig.3.2 Grey scale image

Locating a Sudoku board the supplied image is then preprocessed to locate the Sudoku board using the Edge detection and Perspective Transform systems.

Fig. 3.3 Edge detection

Detecting Circles to remove the entered number system detects the circle (that is made outside of the entered number) the thickness of the circle is increased so that the number inside is not detected.

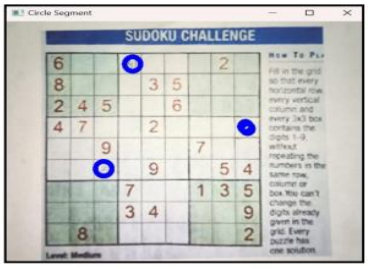

Fig. 3.4 Circle detection

Finding Digits create a model for number detection using Deep Learning and train it on the MNIST Dataset. To detect numbers in an image, the system use a trained model.

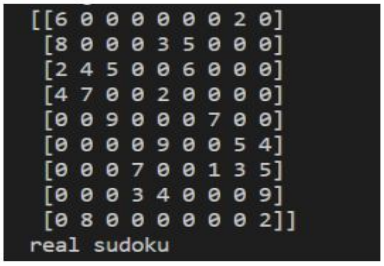

Fig.3.5 Correct Digit Finding

Now that the user has attempted to solve it, we have the genuine Sudoku that was there initially. The system uses the backtracking method to solve the Sudoku puzzle and then shows the user the whole solution. Backtracking is a helpful algorithm for addressing recursion problems since it builds solutions incrementally.

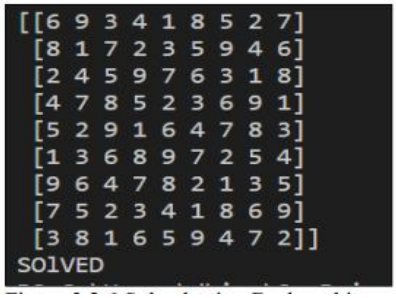

Fig. 3.6 Correct Sudoku Puzzle

Any camera's captured Sudoku puzzles can be partially or fully solved by the Employing Image Processing to extract the Sudoku Puzzle from an image and solving it with a Backtracking algorithm system. The backtracking approach effectively handles these issues because the scale of the image varies from image to image.

IV. Conclusion

Using a backtracking algorithm and image processing, it is possible to recognize and solve Sudoku puzzles from digital photos. This is done by extracting the puzzle from the image and then solving it. The approach makes use of pre-processing methods to identify circles and numbers, and a pre-trained model to identify the numbers and store them in the appropriate spots in the puzzle. The approach can display the solution to puzzles of varied degrees of complexity.

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