

CAMERA, a Cellular Automata Modulation for Estimation Replica Applications

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Abstract:

The CAMERA method is present in the proposed paper, which not only capture image but also it produced audio signals existing in the captured image. This paper presents a method for developing a device which is helpful for the disabled persons who are unable to see environmental objects but they can listens voice. The primary objective of the proposed method is to extract existing objects of the image and produced relevant output in voice format without delaying. Conversion of voice output is very big challenge but the CAMERA method performs their functions in fastest manner. The proposed method uses various image related applications like segmentation, edge detection and corner detection for object extraction. The visibility disability persons can easily use the system due to user friendly nature and such type of persons can perform their daily functions easily without others help. The cellular automata approach is used in the proposed method to achieve objectives. The cellular automata uses frequency modulation to read all possible considerable cells of captured image to provide exact objects and provides desired output using amplitude modulation without delaying any movement.

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I. INTRODUCTION

The device camera is use to capture an image but the proposed method CAMERA is not only capturing device but also produced voice output according to existing objects of the image. The visibility disabled persons facing problems to do their daily routine activities and going for outside places without helping others. The visibility disabled persons can sense the environmental objects by listing output of the proposed projects [1]. The proposed method captures replica or image when ever any different objects occurs as compared to recently captured image and

produced voice output at same time, so the users of the system can timely sense the objects .

The proposed CAMERA method is based on cellular automata techniques. Cellular automata technique is most suitable for the grid based data. The transition function of the cellular automata takes input value of the grid and changes its current value by new value. The new value of grid helps to identify objects from the input data [2]. The identified objects of the input estimated value of grids. Cellular automata are having number of rules based on variety of applications either one-dimensional applications or two-dimensional applications. The CAMERA method is

implemented to process two-dimensional data. The input of the CAMERA method is an image captured by digital camera [3]. The inputted digital image is a two-dimensional data, so the proposed method is convenient to operate the image and find all possible existing objects. The technology of proposed methodology works at different levels on the image [4]. The image level is decided nearby grids of a grid whose next state is to be generated. The nearby grids of a grid are classified in to radius grids. The radius is measured by number of grids, The adjunct grid of a grid consider radius 1, the next grid of adjunct grid is consider as radius 2, next is consider radius 3 and so on. The cellular automata technology of the proposed CAMERA method is known as radius based cellular automata (RBCA) or 2D RBCA [5]. The next section explains 2D RBCA technology in detail.

Manuscript planning: The complete manuscript is organized in five sections. The 2D radius based cellular automata (RBCA) technology is representing in section II, proposed CAMERA method for object segmentation and analogue modulation is representing in section III, Experimental results are representing in section IV. Concluding remarks is given in section V.

II. 2D RBCA TECHNOLOGY

The two-dimensional radius based cellular automata (2D RBCA) are works only on those data, which are arranged in the form of grids or cells (rows and columns) [6]. All the cell may have some specific data is called current state and the current state may change into other forms is called new state according to a specific process. The process, which generates new state, is known as a transition function in cellular automata [7]. Transition function is a rule that may take current state or previous state to generate new state. All the rules of cellular automata may take eight or more neighbours to decide new state. More

number of neighbours provides flexibility to select transition function [8]. 2D RBCA rules are classified in various categories according to type of applications. Type of applications means at which level a user need results. The image applications are dividing in three levels. The first level or lower level applications are targeting only effectiveness of the result, the second or medium level application are targeting effectiveness and efficiency of the result and third or upper level of applications are targeting effectiveness, efficiency and visual quality of result. According to desired results 2D RBCA is categories as follow:

A. 2D ORBCA: Two-dimensional outer radius based cellular automata works on adjunct top, bottom, left, right and diagonal neighbour data [9]. An ORBCA cell may have maximum eight outer neighbour data. The entire outer eight cells contain some numerical value. An image store pixels intensity in the grids. The transition function of ORBCA works on current value of all nearest grids and produce new value either 1 or 0. The value 1 represents black pixels and 0 values represent white pixels.

The ORBCA rule produces a unique function for all the cells to finalise new state. This method has limited number of data to decide transition function but for lower level of applications all the data are sufficient [10]. The RBCA method arbitrary select any cell of the image and generate a unique value for the cell and in the same manner select all the cells of the image and generate unique values for all the cells. The generated unique values of all the cells generate one more aggregate value to works as a transition function. The transition function decides new value or state of all the cells of the inputted image [11].

The following equations help to achieve objectives of ORBCA model. Consider an inputted image $IMG_{m,n}$ contains number of pixels in the form of cells and each cell store one numerical value $VAL_{i,j}$.

$$ORB_m = \sum_{\substack{k=i-1 \\ l=j-1}}^{i+1, j+1} (VAL_{k,l}) - VAL_{i,j}$$

$$ORB_A = ORB_m / N$$

Where ORB_A is the average value of outer cells and N represents total number of cells up to radius 1. The value of N may be from 3 to 8. The value of all the outer cells should be compared with average value of ORB_A and keep only those values whose value is larger than the average value. The value of each cell $VAL_{i,j}$ is compared with ORB_A and store larger value in a vector V_i .

$$V_i = VAL_{i,j} \text{ if } VAL_{i,j} > ORB_A$$

The above equations should be applied on all the cells of the inputted image and create a unique vector UV_i by including all vectors. To calculate universal threshold we should follow the following equations.

$$OCA_M = \sum_{i=0}^{n-1} (UV_i) / n$$

Where the value of n is depends on the number of grids, which are included in the final vector. The final threshold for OCA is calculated by using the following equation.

$$OCA_T = OCA_M + \prod OCA_M$$

Where OCA_T is a threshold value that is use to decides the final state of the all pixels The OCA method compare the value OCA_T with all the cells and generate new state for all the cells by converting the cell value into 1 whose cell value is smaller than OCA_T T otherwise it convert into 0.

$$OCA_{final} = 1 \text{ if } Cell_{i,j} < OCA_T$$

$$OCA_{final} = 0 \text{ if } Cell_{i,j} \geq OCA_T$$

The OCA_{final} is the desired result of the source image. The OCA method is applicable only to works on outer nearest cells and generates new state according to current state of outer adjunct data [12]. OCA method always provides effective results but to achieve better results the source data should be passed to TRBCA method.

B. 2D TRBCA: Totality radius cellular automata works on the entire adjunct cell of on which ORBCA model works including the cell itself [13]. The TRBCA method can provides better results than the ORBCA method by including one more data that is the cell itself and due to inclusive of current cell this method increase efficiency and flexibility of the result. According to TRBCA method each cell may TRBCA have maximum nine input data for transition function to generate new state of the cell [14]. The new state of each cell generated by the TRBCA method is either 1 or 0.

Unlike ORBCA rule, the TRBCA rule also produces unique aggregate value for all the cells to finalise new state. The TRBCA rule includes centred cell with all adjunct cell to finalized next state of the cell. The first step of TRBCA method find sum of all the nine cells values. Consider the source image for TRBCA method is $IMG_{m,n}$, which contains number of cells. The following equation is applied on all the cells for first step. The $VAL_{i,j}$ represents value of the cell and $TRBCA_m$ represents sum of all the nine cells.

$$TRBCA_m = \sum_{\substack{k=i-1 \\ l=j-1}}^{i+1, j+1} (VAL_{k,l})$$

The number of neighbour cells for each cell is from 4 to 9. The following equation is use to finds aggregate value of all the values of nine cells.

$$TRBCA_A = TRBCA_m / N$$

Where $TRBCA_A$ is the average of all nine pixels and N represents total number of neighbours. The possible value of N may be from 4 to 9. The value

of all the possible outer cells and self cell should be compared with aggregate value $TRBCA_A$ and keep only those pixels whose value is larger than the aggregate value. The following equation used to calculate a vector f_k for individual cell.

$$f_k = \bigcup_{i=-1, j=-1}^{i+1, j+1} VAL_{i,j} \text{ if } VAL_{i,j} > TRBCA_T$$

To finalize the common value $TRBCA_T$ for all the pixels of the image, repeat the above process for all the pixels and store aggregate value of all cells in a vector V_{avg} .

$$V_k = \bigcup_{0,0}^{N,M} f_{i,j}$$

The below equations are used to calculate common aggregate value for all the cells.

$$TRBCA_M = \sum_{i=0}^{n-1} (V_k) / k$$

Where the value of k is depends on the number of cells, which are included in final vector. The final transition function for TRBCA is calculated by the following equation.

$$TRBCA_T = TRBCA_M + \prod_0^k TRBCA_M$$

Where $TRBCA_T$ is a common transition value that is use to decides the final state of the all cells. The TRBCA method compares the estimated $TRBCA_T$ with all the cells value and generate new state for all the cells by converting cell value to 1 if the cell value is smaller than $TRBCA_T$ otherwise the cell value is converting into 0.

$$TRBCA_{final} = 1 \text{ if } Cell_{i,j} < TRBCA_T$$

$$TRBCA_{final} = 0 \text{ if } Cell_{i,j} \geq TRBCA_T$$

The $TRBCA_{final}$ is the desired result of the source image using outer totality cellular automata method. The TRBCA method is applicable only to works on outer nearest cells and the pixel itself and generates new state according to current state of all the outer adjunct data. The TRBCA method

provides better results as compare to OCA method by increasing efficiency but to achieve better visual quality of the results than TRBCA method for the same application, the source data should be passed to RBCA method.

C. 2D RBCA: Radius based cellular automata contain neighbours up to n level. The level n may be number of adjunct cells in left, right, top and bottom side [15]. RBCA may contain 8 neighbours up to level 1, 24 neighbours up to level 2, 48 neighbours up to 3 level etc. RBCA method takes neighbours up to n radius or level to produce desired result. The final result of RBCA method contains 1 or 0 value.

To calculate a unique transition function for generate new state; RBCA method includes maximum possible neighbours. Maximum number of neighbours provides more flexibility to select improved transition function and improved transition function always provides efficient results. So, RBCA has more alternative to finalize a strong universal gateway or threshold to achieve better results. Consider $IMG_{m,n}$ is an input data with $M*N$ size. RBCA can select neighbours up to M or N level. The RBCA method calculates transition function for each cell than calculate unique transition function by using transition functions of each cell. The below equations are used to calculate threshold for each cell $Cell_{i,j}$.

$$RBCA_a = \sum_{0,0}^{i,j} Cell_{i,j} \text{ if } i \leq k \text{ and } j \leq k$$

$$RBCA_A = RBCA_a / P$$

Where

$$P = \bigcup_1^k P + Q * 8, Q = Q + 1 \text{ where } p = 0 \text{ and } Q = 1$$

The $RBCA_A$ is compared with all the neighbours up to k level and store in vector VR_n only those neighbours which are greater than $RBCA_A$.

$$VR_k = \bigcup_{i=0, j=0}^{k,k} Cell_{i,j} \text{ if } Cell_{i,j} > RBCA_A$$

The above equations are applied on all the pixels and store estimated values in the final vector FVR.

$$FVR_R = \bigcup_{i=0}^k \bigcup_{j=0}^k VR_j$$

The values of final vector are used to estimate unique gateway or threshold for RBCA. The unique gateway is calculated by using the following equations.

$$RBCA_M = \sum_{i=0}^{R-1} (FVR_R) / R$$

$$RBCA_T = RBCA_M + \prod_{i=0}^R RBCA_M$$

$RBCA_T$ is the unique gateway for all the cells to decide final state. The unique value of $RBCA_T$ is compared with all the cells and generates new state for all the cells whose value is smaller than the unique gateway.

$$CellState_{i,j} = NewState_{i,j} \text{ if } Cell_{i,j} < RBCA_T$$

The estimated new state of a cell may be 1 or 0. The unique gateway provides better result and help to achieve desired output for all applications.

III. PROPOSED CAMERA METHOD

An image has large number of pixels in the form of grids. Each grid of an image is having a numerical value and if the value of grid is changed than the pixel quality may be increased or decreased. The proposed method change value of grid as a new state, but maintain current quality during process and produce improved results. The proposed CAMERA method has two primary modules CAM method and modulation to achieve desired objectives. The figure 1 shows block diagram of proposed CAMERA method.

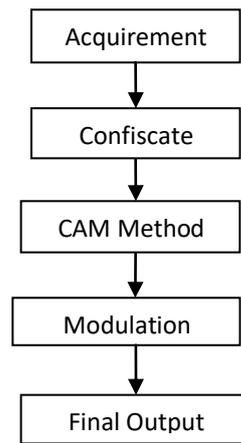


Figure 1: Block Diagram of Proposed method

A. Acquirement or Sensing: - The proposed method starts their work by taking input of an image. The proposed can use any image capturing device to starts their process.

B. Confiscate or Blur exclusion: - The CAM can take image in light and dark zone, the images taken in dark zone may have various types of blurs. The proposed method used Gaussian filter to smooth the image [16]. Consider $F_{i,j}$ is the image send by previous step. The following equations followed by the filter to smooth the image:

$$G(i,j) = e^{-\frac{i^2+j^2}{2\sigma^2}}$$

Where σ determines the degree of smoothing and masks size increases with σ .

$$F(i,j) = \nabla^2 [G(i,j) * F(i,j)]$$

$$F(i,j) = \nabla^2 G(i,j) * \nabla^2 F(i,j)$$

Where

$$\nabla^2 G(i,j) = \left(\frac{i^2 + j^2 - 2\sigma^2}{\sigma^4} \right)^{-(i^2+j^2)/2\sigma^2}$$

Output of this step is noise free image and the output is passed to next step for further processing.

C. CAM Method: - The CAM (Cellular Automata Mean) method is applicable to process image by maintaining quality of pixels. This step takes input

from the confiscate step, the confiscate step can send number of images for processing. The CAM method takes all the images and stores all the images in the form of array. CAM method segments the image and finds all possible objects. The CAM method is based on RBCA technology explained in previous step to segment the image. The CAM method process inputted series of images and finds all the objects as soon as possible and pass to next step modulation for producing audio output. The working principle of object segmentation CAM method is shows in figure 2. The working of CAM method starts with sensing an image, follow number of steps and ends with finding object of the sensed image. The steps of CAM method is as follow:

i. Image Array:- This step of CAM method stores all the inputted images in an array D_{queue} . The array is dynamic array which can store number of data. The CAM method can process only one image at a time, so this step all the images one by one to next step and removes from the array. The array works like dynamic queue, which works on first in first out concepts.

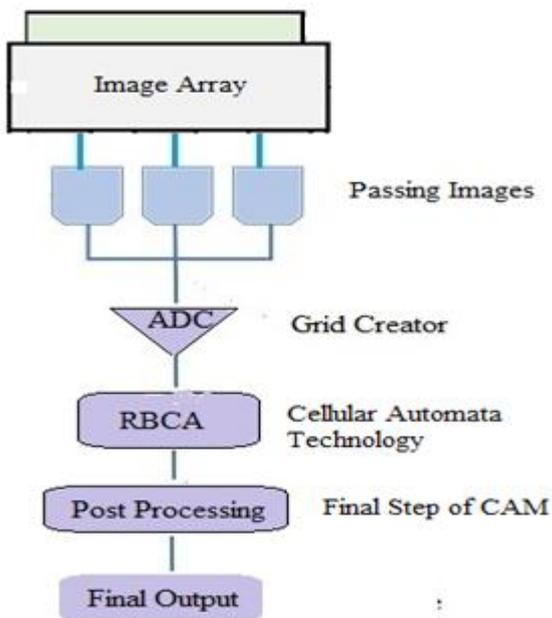


Figure 2: Working Principle of CAM

ii. Transformation: - The RBCA method works on the data which are in the form of grid. So, the CAM method converts the enhanced image into form of grid. Consider $F_{i,j}$ is the enhanced image produced by confiscate step. Consider $[x,y,z]$ is the size of image $F_{i,j}$ passed by previous step. The

following equations are use to transfer image in the form of cells or grids. $MAT(i, j) = im2gray(F_{i,j})$ if $z = 3$

$$MAT(i, j) = \sum_{i=0, j=0}^{i=x, i=y} F_{i,j} \text{ Otherwise}$$

The transformed image passed to next step for continue the processing.

iii. Vector formation: - The CAM method works only on grid based data. So, the grid $MAT_{i,j}$ generated by previous step is the input of this step. The vector formation step takes each grid and create local vector for all the grids. The following equations create local grid for all the grids:

$$V_A = \sum_{\substack{k=i+1 \\ l=j+1 \\ k=l-1 \\ l=j-1}}^{k=i+1 \\ l=j+1} MAT_{k,l}$$

$$LV_B = \sum V_A \text{ where } V_A > avg(V_A)$$

The local vector is creating for all the grids or cells using the same equations, than create global vector using all the created local vectors. The following equation helps for create global vector.

$$GV_P = \sum_{cell=0}^N LV_B \text{ where } N \text{ represents number of cell}$$

The Global vector GV_P is the vector, which is having only good quality grids. The global vector is use to decide the final transition function.

iv. Final Transition Function: - Final transition function is the last step of RBCA model and the transition function is use to process an image for segment all objects. This step reads global vector GV_P produced by last step and find an estimated value. The estimation process follow the equations:

$$M = \sum GV_P$$

$$T = M + \prod_0^P GV_P$$

The T produced by RBCA is the common transition function for image segmentation. The transition function T is always produced effective,

efficient and improved eminence results. The next step of CAM method use transition function T to segment the inputted image.

v. Post Processing: - This step is the last step of CAM method. The CAM method takes images from the image array one by one and transition function of RBCA model. The transition function T processes all the cells of image and produce possible objects. Consider $Cell_{i,j}$ are the cells of inputted image and the following equation helps to segment the image:

$$Output_{i,j} = Cell_{i,j} \text{ if } Cell_{i,j} > T$$

The $Output_{i,j}$ is the segmented image, which consist of all the existing main objects in the image. The segmented image is passed to next step for modulation.

D. Modulation: - This step takes output of CAM method and applies DSBC (Double Side Band with Carrier) modulation technique [17] to produce output in analogue format. Any type of audio playing system is able to play an output generated by CAMERA method. The structure of DSBC modulation on CAM output data is shows in figure 3.

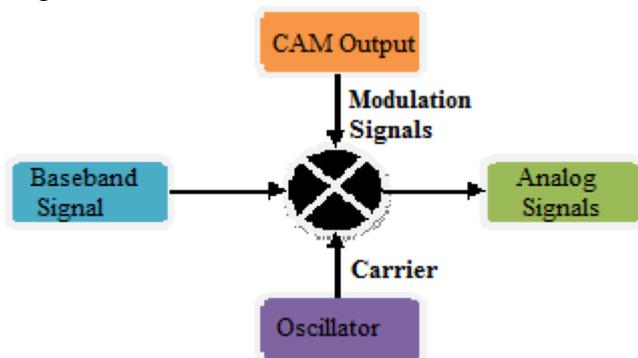


Figure 3: DSBC Modulation Structure

The term modulation is a process, which convert one form of data in other form [18]. The proposed CAMERA method use baseband and carries with output of CAM to produce audio output. The proposed method take carrier signal $C(t)$ and baseband signals $Bb(t)$ according to following equations:

$$CS(t) = A\cos(2\pi ft)$$

$$BS(t) = B\cos(2\pi ft)$$

Where f is represent frequency of signals. The general modulation approach of the proposed method is as follow:

$$M(t) = E_{carrier} + E_{baseband}$$

To generate waves of the general modulation, the carrier and baseband signals are generalized using the following expressions:

$$E_{carrier} = \lim_{T \rightarrow \infty} \frac{1}{T} \int_{-T/2}^{T/2} CS(t) dt$$

$$E_{carrier} = \lim_{T \rightarrow \infty} \frac{1}{T} \int_{-T/2}^{T/2} A\cos(2\pi ft) dt$$

$$E_{baseband} = \lim_{T \rightarrow \infty} \frac{1}{T} \int_{-T/2}^{T/2} BS(t) dt$$

$$E_{baseband} = \lim_{T \rightarrow \infty} \frac{1}{T} \int_{-T/2}^{T/2} B\cos(2\pi ft) dt$$

The normalized waves of carrier and baseband applied on input data and produced desired output.

$$A_{output} = M(t) + Output_{i,j}$$

The produced result A_{output} of carrier signal, baseband signal and output of CAM method is in the form of analogue waves. The produced waves are able to run in any audio player. The modulation operation is represented in the figure

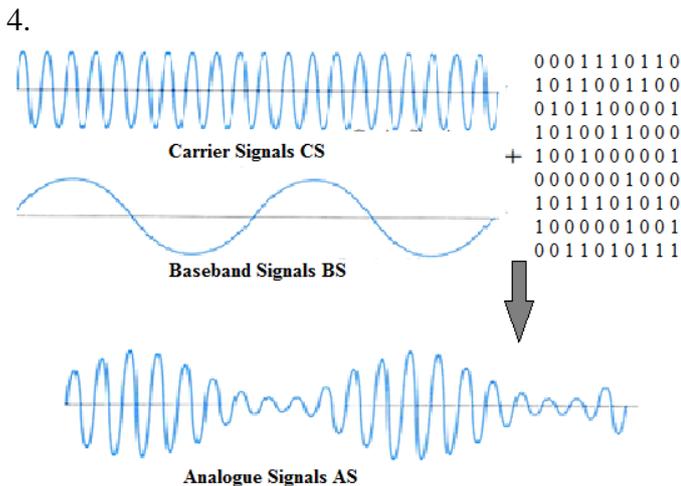


Figure 4: CAMERA method Modulation operations

The complete process of CAMERA method is represented in the following algorithm:

Step 1: Input series of images

Step 2: Filter all images using Gaussian filter to remove noise.

Step 3: Store all images in a dynamic array D_{queue} and send all images in FIFO manner. Consider first image taken from array is $F_{i,j}$.

Step 4: Convert the image into grid form.

```
[x,y,z]=size(Fi,j)
if (z==3)
MAT(i,j) = im2gray(Fi,j)
else
for(i=0 to x)
for(j=0 to y)
MAT(i,j)=IM(i,j)
```

Step 5: Create a level vector LV for each grid and final or global vector FV for all vectors. Consider $GR_{i,j}$ is the arbitrary selected grid or cell from $MAT(i,j)$.

```
Set p=1, N=0, S=0
Set k=i-p
For (i=k to i+p)
For(j=k to j+p)
LVr=GRi,j
S=S+ GRi,j
N++
p++
A=S/N
```

Step 6: The mean value A is compared with all the values of level vector and select only larger value grids for final vector level.

```
For (r=0 to N-1)
If LVr>= S
FLVc= LVr
c++;
```

Step 7: Step 4 to step 6 repeats for all the grids and store the value of final level vector $FLV_{l,c}$ to final vector FV.

```
For (i=0 to L)
For(j=0 to c)
FVk= FLVl,c
K++
```

Step 8: The final vector FV is used to calculate final or global transition function T.

```
Len=length(FV);
Set Sum=0
For (i=0 to Len-1)
Sum=Sum+FV[i]
R=Sum/Len
Set R1=0
For(i=0 to L-1)
FVV[i]=FV[i]-RBCA
R1=R1+FVV[i]
T=R+R1
```

Step 9: The transition function T is applied on all the grids and generate new state for all the grids.

```
Set front=0
Rear=length(Dqueue)
While(front<rear)
F= Dqueue(front)
M,N=sizeof(F)
For (i=0 to M)
For(j=0 to N)
If(Fi,j> T)
Fi,j = 1
Else
Fi,j = 0
front++
```

Step 10: Apply modulation technique on $F_{i,j}$ to generate analogue signals AS with the help of Carrier signals CS and Baseband signals BS.

```
For (i=0 to M)
```

For(j=0 to N)

$$AS = CS + BS + F_{i,j}$$

The output AS produced by the proposed method is in the form of analogue waves. These waves are able to play in audio player. The blind disabled persons could be listen produced audio and sense the major objects in front of their image captured device. The next section shows efficiency and effectiveness of the proposed CAMERA method.

IV. EXPERIMENTAL RESULTS

The efficiency of CAMERA method is depends on the efficiency of CAM method, so if the CAM finds exact objects than the proposed CAMERA method apply modulation operation and compares the objects of output image the objects of database and perform modulation operations. The experimental result shows efficiency of CAM method.

The CAM method is applied on number of images to find their existing objects and output shows existing major objects. The figure 5 shows only limited input and output images, but the method is experimented on number of images.

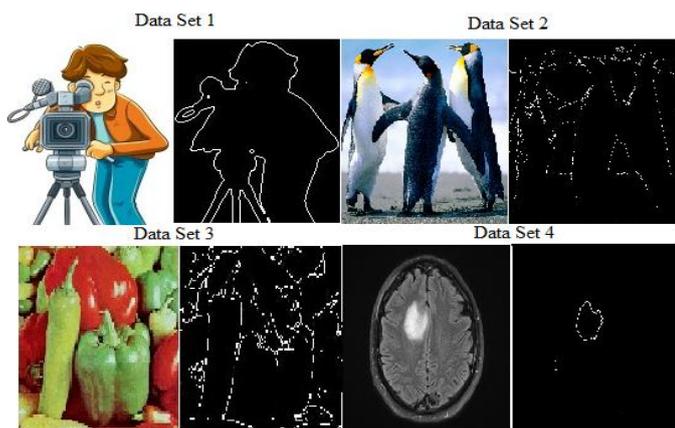


Figure 5: Experiment Data Set

The experimental result first image is input and second image is output image. The output image shows all major objects in the form of dotted lines. The edges of objects are continuous lines, but depend on quality of input image. The CAM

method performs better results if users use high resolution device to capture image.

The efficiency of CAM method is justified using the image quality measurement parameters like MSE (Mean Square Error), PSNR (Peak Signal Noise Ratio)[19], MAE (Mean Absolute Error)[20], SC (Structural Contents), AD (Additive Difference) and NoB (Number of Objects)[21]. The table 1 shows different data of IQMP (Image Quality Measurement Parameters) of experimented data produced by proposed CAM method.

Table 1: Produce IQMP data on the basis of experimental results according to figure 5.

| IQMP | CAM Method | | | |
|------|------------|------------|------------|------------|
| | Data Set 1 | Data Set 2 | Data Set 3 | Data Set 4 |
| MAE | 1.8 | 2.8 | 3.2 | 2.1 |
| PSNR | 2.99 | 1.99 | 1.79 | 1.86 |
| MAE | 0.75 | 0.95 | 1.15 | 1.35 |
| SC | 1.85 | 1.65 | 1.75 | 1.51 |
| AD | 2.46 | 2.10 | 1.46 | 2.05 |
| NoB | 1.98 | 3.4 | 4.68 | 1.00 |

The efficiency of CAM method is also represented using graph. The figure 5 shows a bar chart on the same data discussed in table 1.

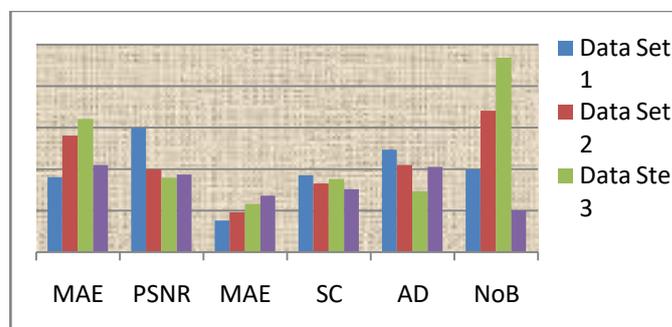


Figure 5: A bar chart on the data produced by CAM

The NoB of experimental images shows the possible objects and other parameters shows quality of produced result. The bar chart also helps to express the efficiency of CAM method. Hence the CAMERA method also produces effective and efficient results and it's very useful for the needy persons.

V. CONCLUSION

This paper presents a cellular automata based method for image objects segmentation and analogue signals modulation. The proposed method has two primary modules CAM and modulation. The CAM method is based on radius based cellular automata to extract all major objects of an image. The RBCA is a grid based technology, which can processes images. The CAM method works efficiently to find objects and passed processed image to modulation operation. The modulation operation take input from CAM method and use baseband and carrier signals for modulation of analogue signals.

The proposed method is very helpful for blind disabled persons. The blind person can install the method in any device like camera and mobile. The method can easily use mobile camera and audio player for their input and output. Using mobile or camera the blind persons can easily sense objects in front of their image capturing device.

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