# Application of Brain Tumor Detection on DSP Environment using TMS320C6713 DSK

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***Abstract*—Medical image processing continues to enable the biomedical technology revolution that we are experiencing today. In this brief paper the main purpose of the project is to carry out a new cooperative approach for brain tumor segmentation and feature extraction from Magnetic Resonance Imaging with the good accuracy. The basic process involves is to use the notion of the modified Fuzzy C-Means which incorporates the spatial information and also in order to improve the segmentation and to get a better estimation of the final clusters centers. Then FCM_S results are considered as an initialization of the active edge for the Level sets algorithm. Digital Signal Processor chip of Texas instruments TMS320C6713 DSK with the Code Composer Studio and Matlab Simulink Blocksets are used for implementing this proposed work. The performance is measured by including some various optimization techniques and all results are shown using C67613 Graphical User Interface. The Development Starter Kit is also studied for available resource and their appropriate usage.**

***Keywords*—Code Composer Studio; Fuzzy C-Mean; K-means; Level sets; TMS320C6713 DSK**

## I. Introduction

MRI Image processing is an active research area which has become a vital component of a large number of biomedical applications. MRI is an important imaging technique for detecting abnormal changes in tissues and organs. In computer vision, image processing is a highly challenging field that image segmentation still a broad research topics and also an essential task in many applications because it plays a major role in the MRI image understanding. The MRI Images segmentation [1] has become the focus of contemporary research that some applications requires a simple division of image into homogeneous regions while others require more accurate detection [3], for this reason we need a special unit that we use for digital signal and image processing in a real time execution and also the high speed data transfer.

Digital signal processor [5] is one of the core technologies in rapidly growing application that become a key component in many domains. Digital signal processors [6] such as the TMS320C6x family of Texas Instruments are like fast special-purpose microprocessor with a specialized type of architecture and an instruction set appropriate for signal processing. All DSP techniques have been very successful because of the development of low-cost software and hardware support. The proposed algorithm will implement practically on our hardware

## II. MRI Image Processing

### A. MRI Image Acquisition

MRI is a modern imaging technique that it gives a more detailed image than CT scans and X-rays. MRI scans uses a large magnet field or radio waves to take brain image and other structure of the body. High spatial resolution and excellent soft tissue diagnosis are the advantages of MRI over other medical imaging techniques. In our research, the input MRI images are simulated with T1-weighted contrast and all image are obtained from the Brainweb database from McConnell Brain Imaging Center of Montreal Neurological Institute at McGill University.

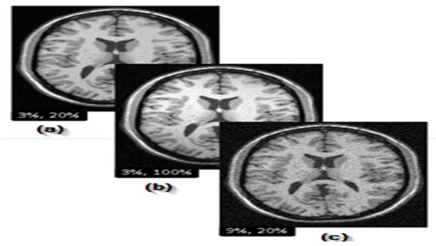



Fig. 1. Brain MRI Images: (a): 3% Noise and 20% Inhomogeneity; (b): 3% Noise and 100% Inhomogeneity; (c): 9% Noise and 20% Inhomogeneity.

### B. Image Segmentation Methods

Segmentation is the division of an image into regions or categories which correspond to different objects or parts of objects [8]. Every pixel in an image is allocated to one of a number of these categories. It is an essential step in image processing and also it is a critical stage of image analysis. To define the segmentation: supposing image is represented by W, Let W denotes the whole image region Ri and i=1, 2,….., k are disjoint nonempty regions of W, consists following conditions:

$$\cup_{i=1}^{k} R_i = W \quad (1)$$

Image segmentation methods can be classified into three categories [4]: Edge-based, region-based, and pixel-based methods. Clustering and edge detection are an important tool for a variety of medical applications. In this study, in order to detect the brain tumor from MRI images a combination of some image segmentation methods are used that are: K-means clustering, the Level Sets, and the Fuzzy C-Mean Method [12].

## III. Description of Hardware and Software Tools

In this section, the paper will discuss about the hardware and software tools that are used in our proposed work, that are:

### *A. TMS320C6713 DSK*

The TMS320C67x devices of digital signal processors are floating-point DSPs in C6000 platform. TMS320C6713 DSK is a development board of "TI Inc." inexpensive, C6713 DSK is a platform of low-cost autonomous development and also is based on the high-performance that enables users to evaluate and develop applications on hardware Kit. The simplified architecture of TMS320C6713 is shown in the Figure. 2 below:

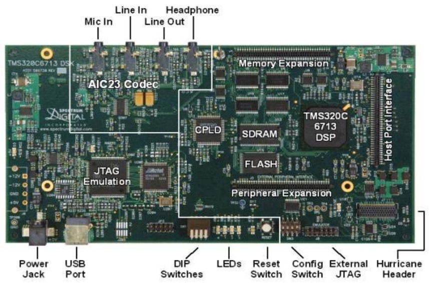



Fig. 2. Texas Instruments C6713 Hardware Development Kit.

This platform contains various hardware components that support some interesting features. Some of the key features are:

- A Texas Instruments TMS320C6713 DSP Core 32 Bit floating point processor that operating at 225 MHz.
- 04 user accessible LEDs and DIP switche, boot options, and standard expansion connectors for daughter card.
- An AIC23 stereo codec, Interface or external emulator, 16 MB of SDRAM, Single voltage power supply (+5V).
- Software board configuration through the registers implemented in CPLD, HPI boot mode, 32 Bit EMIF.
- .JTAG (Joint Test Action Group) emulation through on-board JTAG emulator with USB host, external emulator
- 512 KB of non-volatile Flash memory (256 KB usable in default configuration) and 264KB of internal memory

### *B. Code Composer Studio*

The CCS software is an Integrated Development Environment (IDE) used to develop applications targeted to Texas Instrument's such Digital Signal Processors. Three tools, namely the C compiler (similar to linear optimizer), assembler and linker are used to generate an executable program from C source or assembler (.asm). It has graphical capabilities and supports real-time debugging. CCS provides an easy-to-use software tool to build programs. For each application to be run on the C6713 processor, one must create a "project" in the CCS which puts together all information about the required C source files, header files, C libraries, C compiler, linker, build options.

### *C. Embedded Target For Texas Instrument C6000*

Embedded IDE Link provides a connection between Matlab and CCS which the Simulink Embedded Target converts our Simulink model into a CCS Project. With IDE we can use Matlab and Simulink to analyze, shape and correct the behavior of running code. Another possible use for automation is to create Matlab scripts that verify and examine the algorithms running in their final run. The Relationship between MATLAB, CCS and Texas Instrument DSP is shown in Fig. 3.

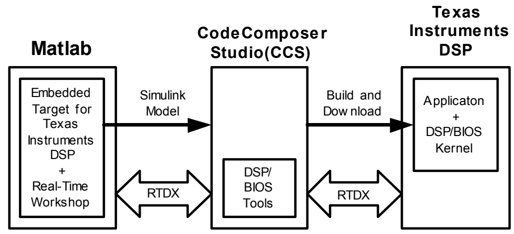



Fig. 3. Link between DSP Simulink and Code Composer Studio.

## IV. Proposed Methodology

In this research, an efficient algorithm is proposed for brain tumor detection based on the segmentation of MRI images by using the modified Fuzzy C-Means [2] and level sets algorithms [11]. Proposed system has divided into parts. The output obtained from one part is taken as input to the next part. This can be represented by the block diagram show in figure 4.

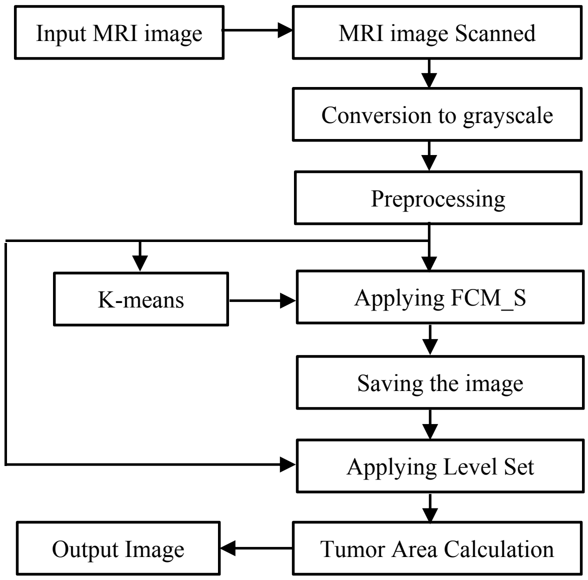



Fig. 4. Proposed Block Diagram.

The proposed system has been developed to solve the problem of initial parameters for the level set algorithm such as the initial contour and its center. For that reason, it was used a technique called a modified Fuzzy C-Means with spatial constraints denoted: FCM_S which allows us to act on the MRI image using the global information and provides easily interpretable membership cards [10]. It would be interesting to combine the region based and edge based model, since they improved the classification [7]. With using this new proposed approach the noises are reduced and the problem of intensity inhomogeneity is solved and also we can obtain high accuracy image and the overall efficiency of a system will be enhanced.

One solution is to modify the FCM's objective function in order to minimize the effect of inhomogeneity and to expect a better classification. Modified objective function is defined as:

$$J_{FCM\_S} = \sum_{j=1}^{N}\sum_{k=1}^{C} U_{jk}^{m}\left\|y_j - v_k\right\|^2 + S \quad (2)$$

Where S takes S1 (mean of neighboring pixels) or S2 (median of neighboring pixel) as first and second FCM variant:

$$S1 = \sum_{j=1}^{N}\sum_{k=1}^{C} U_{jk}^{m}\left\|\bar{y}_j - v_k\right\|^2 \quad (3)$$

$$S2 = \sum_{j=1}^{N}\sum_{k=1}^{C} U_{jk}^{m}\left\|\tilde{y}_j - v_k\right\|^2 \quad (4)$$

The membership function is given by:

$$U_{jk} = \frac{\left(\|y_j-v_k\|^2+\alpha\|\bar{y}_j-v_k\|^2\right)^{\frac{-1}{m-1}}}{\sum_{k=1}^{C}\left(\|y_j-v_k\|^2+\alpha\|\bar{y}_j-v_k\|^2\right)^{\frac{-1}{m-1}}} \quad (5)$$

And the clusters centers are calculated by:

$$v_k = \frac{\sum_{j=1}^{N} U_{jk}^{m}\left\|y_j-\alpha\bar{y}_j\right\|^2}{(1+\alpha)\sum_{j=1}^{N} U_{jk}^{m}} \quad (6)$$

Where No. of clusters k=4, the initialization of clusters centers is made by the K-means algorithm, α: control the effect of the neighbors (if α=0 we obtain standard FCM) [9]. For the statistical properties of neighboring pixels, we used a 3x3 mask, where FCM_S1 is based on calculation of the mean of these neighbors and FCM_S2 for the median. After applying FCM_S, we choose the fuzzy cluster to define initial contour [16] for level set method then we use above contour in input image in level set to obtain desired image segmentation. The edge detection process done by using the dynamic variational boundaries to approximate the evolution of the active contours implicitly by tracking the zero level set Γ(t) using equation (7).

$$\begin{cases} \emptyset(t,x,y)<0 & x,y \text{ is inside } \Gamma(t) \\ \emptyset(t,x,y)=0 & x,y \text{ at } \Gamma(t) \\ \emptyset(t,x,y)>0 & x,y \text{ is inside } \Gamma(t) \end{cases} \quad (7)$$

In the last step of this proposed approach, the tumor area calculation using binarization method is done. The binary image can be represented as a summation of total number of white and black pixels. It calculates [12] the size of the tumor by calculating only the number of white pixels (digit 0).

## V. IMPLEMENTATION

Once proposed algorithm was developed, it was completely verified in Matlab with multiple input images. Then the in-built functions of MATLAB [14] were replaced by user-defined functions in Matlab Simulink Model that we uses different Blocksets of "Video and Image Processing Blockset" library. The proposed DSP simulink model (design) is shown in Fig. 5.

TABLE I. DIFFERENTS SIMULINK BLOCKSET USED

| N° | Matlab Simulink Blocksets | | |
|---|---|---|---|
| | ***Blocks*** | ***Library*** | ***Quantity*** |
| 1 | Image from file | Sources | 01 |
| 2 | Median filter | Analysis & Enhancement | 01 |
| 3 | Video viewer | Sinks | 02 |
| 4 | Embedded MATLAB function | User-Defined Functions | 04 |
| 5 | Image data type conversion | Conversions | 03 |

On Matlab Simulink, there is a library containing a specific blocks for each type of DSP card, from this library we add the C6713 block then we selects processor type and also clock frequency value. Concerning the passage from DSP Simulink Model to the Code Composer Studio, MATLAB has developed a tool "Link for code composer studio" which allowed him to communicate with the Code Composer Studio for compilation, real time debugging, and linking program in Integrated Development Environment (IDE). So with using these tools, the proposed Simulink is translated into CCS project written in C language that could be compiled using a highly optimizing C/ C++ Compiler and run on the TMS320C6713 DSP. The next step is to compile C code creating, so the Build command will compile all the files that are included in this project and make an executable file then we load the executable file (.out).

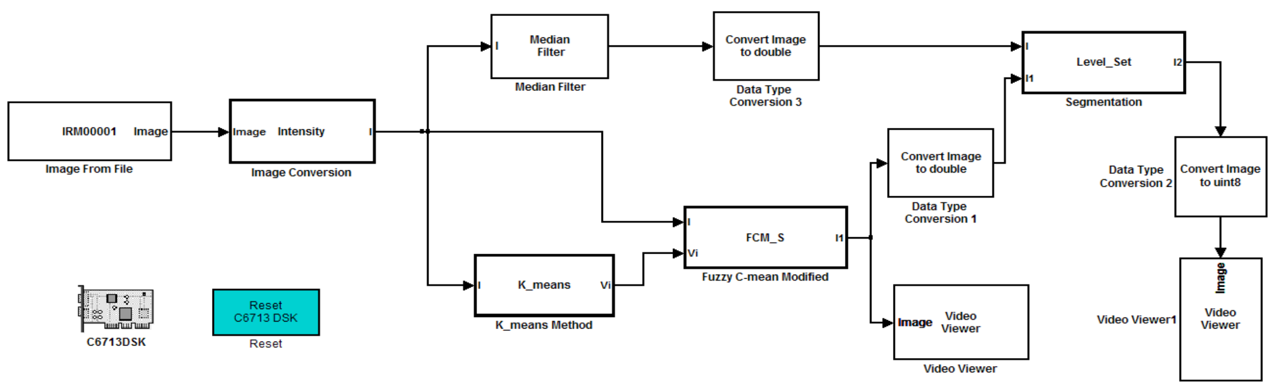



Fig. 5. Flowchart of the Proposed Simulink Model.

## VI. RESULTS AND DISCUSSION

In this section, some of the brain MRI images containing tumor taken for testing our proposed algorithms are shown as:

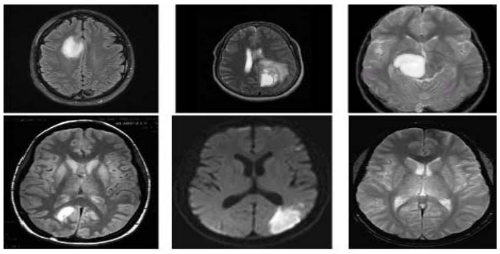
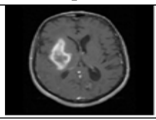
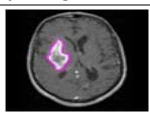
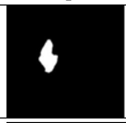
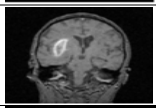
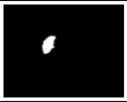
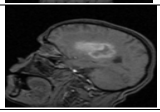
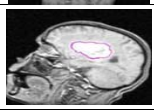
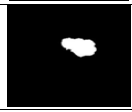


Fig. 6. Brain MRI images containing tumor.

Now, we present the obtained results after successful execution in CCS v3.1 and real time implementation on C6713. Table II has shown the MRI data results of a proposed system.

TABLE II. EXPERIMENTAL RESULTS

| **Sections** | **MRI Data Results** | | |
|---|---|---|---|
| | ***Input*** | ***After segmentation*** | ***Output*** |
| Axial |  |  |  |
| Coronal |  |  |  |
| Sagittal |  |  |  |

MCR (Miss Classification Rate) is calculated to evaluate the segmentation results. Table III shows the MCR percentage in these proposed algorithms. The MCR can be expressed as:

$$MCR = \frac{\text{Number of misclassified pixels}}{\text{Total number of pixels}} \times 100\% \qquad (8)$$

TABLE III. MCR FOR PROPOSED METHODS

| **Methods** | **Noise and Inhomogeneity** | | |
|---|---|---|---|
| | ***Axial*** | ***Coronal*** | ***Sagittal*** |
| Standard FCM | 22.18 | 12.48 | 15.88 |
| FCM + K-means | 21.75 | 12.07 | 15.37 |
| FCM_S1 + K-means | 12.58 | 8.16 | 7.81 |
| FCM_S2 + K-means | 10.64 | 6.25 | 5.98 |

To validate the obtained results, the SA (Segmentation Accuracy) was calculated by using the equation (9). Also the performance comparison [15]: No. of iterations (Convergence Rate), SA Segmentation Accuracy and Tumor area calculation were summarized in the figure 6, 7, 8 for all differents sections.

$$SA = \frac{\text{Number of correctly classified pixels}}{\text{Total number of pixels}} \times 100\% \qquad (9)$$

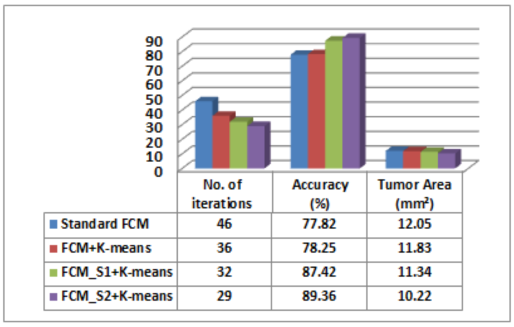



Fig. 7. Performance comparison for Axial Section.

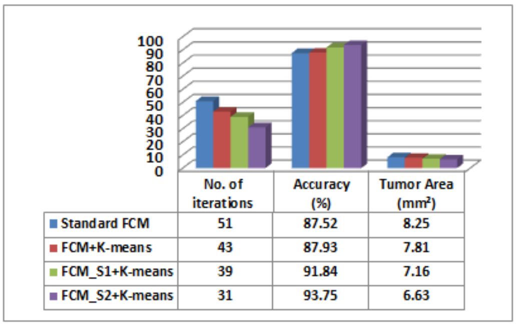



Fig. 8. Performance comparison for Coronal Section.

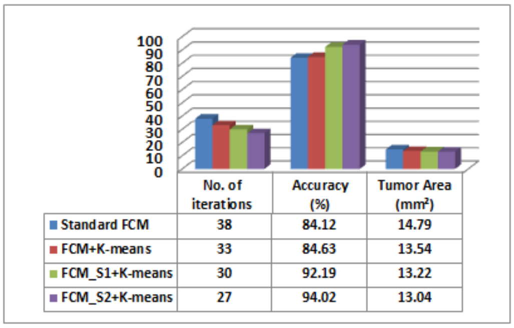



Fig. 9. Performance comparison for Sagittal Section.

This results show that FCM is sensitive to noise and intensity inhomogeneity [12], also it can be observed that the FCM_S2+K-means demonstrate the best performance with the least % of MCR and improved the quality of the classification.

## VII. OPTIMIZATION

In order to improve the total execution time on the chip, various optimization techniques were used to check the performance: C code, CCS compiler and L2 cache memory. The TMS320C6713 DSK provides a feature to change the size of L2 cache memory from 0 KB to 256 K Bytes; it can be made by changing the parameters in the General Extension Language (gel file). The number of clock cycles required for each function is calculated and compared by a method called profiling for benchmark. In our methodology of profiling, all of its functions were analyzed and tested to determine the values of clock cycles. The improved performances after adding the presented optimization techniques are shown in the table II.

TABLE IV. PERFORMANCE IMPROVEMENT ACHIEVED

| N° | Using Optimization Techniques | | |
|---|---|---|---|
| | ***Function*** | ***No. of CPU Cycles (Without Optimization)*** | ***No. of CPU Cycles (With Optimization)*** |
| 1 | Image conversion | 3924756 | 3131025 |
| 2 | Median filter | 91295273 | 73084236 |
| 3 | K_means | 95877799 | 90436952 |
| 4 | Convert image to double | 3402892 | 2935339 |
| 5 | FCM_S1 | 98642594 | 92527099 |
| 6 | FCM_S2 | 98623241 | 91348615 |
| 7 | Level Set | 93635675 | 89908543 |
| 8 | Convert image to uint8 | 3745278 | 2978543 |

## VIII. CONCLUSION

In this paper, we proposed a new robust approach to brain tumor segmentation and its area calculation using modified Fuzzy C-mean and level set algorithms. The proposed method was experimented with MRI scanned images of human brain and if there is any noise or intensity inhomogeneity present, it was removed by using the median filter and also with the modified FCM process. The implementation of brain tumor detection algorithm is done. Also the performance of this proposed algorithm has been tested on several MRI images and provides very satisfactory results. The experimental results show that our proposed approach for brain tumor detection is able to improve the quality of image segmentation and also give the high diagnosis accuracy. Finally the approximate reasoning for calculating the tumor shape can be carried out.

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