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(57) Abstract :
A method and apparatus for 3D biomedical image reconstruction, employing advanced computational algorithms, adaptive filtering techniques, and artificial intelligence methodologies. The system provides high-definition 3D reconstructions from various imaging modalities while ensuring swift processing times. The adaptive filters mitigate distortions, and the AI-driven process enhances image quality and provides deeper data analysis. With an emphasis on personalization, the invention tailors reconstructions to individual patient data, making it valuable for both clinical and research applications. Accompanied Drawing [FIGS. 1-2]

No. of Pages : 18 No. of Claims : 10

"**FORM 1** THE PATENTS ACT 1970 (39 of 1970) and THE PATENTS RULES, 2003 **APPLICATION FOR GRANT OF PATENT** (See section 7, 54 and 135 and sub-rule (1) of rule 20)				(FOR OFFICE USE ONLY)	
		Application No.			
		Filing date:			
		Amount of Fee paid:			
		CBR No:			
		Signature:			
1. APPLICANT'S REFERENCE / IDENTIFICATION NO. (AS ALLOTTED BY OFFICE)					
2. TYPE OF APPLICATION [Please tick (✓) at the appropriate category]					
Ordinary (✓)		Convention ( )		PCT-NP ( )	
Divisional ( )	Patent of Addition ( )	Divisional ( )	Patent of Addition ( )	Divisional ( )	Patent of Addition ( )
3A. APPLICANT(S)					
Name in Full		Nationality	Country of Residence	Address of the Applicant	
Andhra University		Indian	India	Visakhapatnam, Andhra Pradesh, India. Pin Code: 530003	
3B. CATEGORY OF APPLICANT [Please tick (✓) at the appropriate category]					
Natural Person ()		Other than Natural Person			
		Small Entity (✓)	Startup ()	Others ()	
4. INVENTOR(S) [Please tick (✓) at the appropriate category]					
Are all the inventor(s) same as the applicant(s) named above?		Yes ()		No (✓)	
If "No", furnish the details of the inventor(s)					
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1. Prof. James Stephen Meka		Indian	India	Dr. B. R. Ambedkar Chair Professor, Dean, A.U. TDR-HUB, Andhra University, Visakhapatnam, Andhra Pradesh, India. Pin Code: 530003	

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5. TITLE OF THE INVENTION

"A METHOD AND APPARATUS FOR 3D BIOMEDICAL IMAGE RECONSTRUCTION"

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~~**8. IN CASE OF APPLICATION CLAIMING PRIORITY OF APPLICATION FILED IN CONVENTION**~~

~~COUNTRY, PARTICULARS OF CONVENTION APPLICATION~~

~~Country~~	~~Application Number~~	~~Filing date~~	~~Name of the applicant~~	~~Title of the invention~~	~~IPC (as classified in the convention country)~~

~~9. IN CASE OF PCT NATIONAL PHASE APPLICATION, PARTICULARS OF INTERNATIONAL APPLICATION FILED UNDER PATENT CO-OPERATION TREATY (PCT)~~

~~International application number~~	~~International filing date~~

~~10. IN CASE OF DIVISIONAL APPLICATION FILED UNDER SECTION 16, PARTICULARS OF ORIGINAL (FIRST) APPLICATION~~

~~Original (first) application No.~~	~~Date of filing of original (first) application~~

~~11. IN CASE OF PATENT OF ADDITION FILED UNDER SECTION 54, PARTICULARS OF MAIN APPLICATION OR PATENT~~

~~Main application/patent No.~~	~~Date of filing of main application~~

12. DECLARATIONS

i) Declaration by the inventor(s)

(**In case the applicant is an assignee**: the inventor(s) may sign herein below or the applicant may upload the assignment or enclose the assignment with this application for patent or send the assignment by post/electronic transmission duly authenticated within the prescribed period).

I/We, the above named inventor(s) is/are the true & first inventor(s) for this Invention and declare that the applicant(s) herein is/are my/our assignee or legal representative.

(a) Date 25/08/2023

(b) Name	(c) Signature
1. Prof. James Stephen Meka 2. Mr.Anirudh Edupuganti 3. Mr.I.Ravi Kumar 4. Mr.K. Joseph Noel 5. Mrs.K.V.Lakshmi 6. Mrs.Malla Sirisha	

~~(ii) Declaration by the applicant(s) in the convention country~~

~~(In case the applicant in India is different than the applicant in the convention country:~~ ~~the applicant in the convention country may sign herein below or applicant in India may upload the assignment from the applicant in the convention country or enclose the said assignment with this application for patent or send the assignment by post/electronic transmission duly authenticated within the prescribed period)~~

~~I/We, the applicant(s) in the convention country declare that the applicant(s) herein is/are my/our assignee or legal representative.~~

~~(a) Date~~

~~(b) Signature(s)~~

(c) ~~Name(s) of the signatory~~

(iii) Declaration by the applicant(s)

I/We the applicant(s) hereby declare(s) that: -

- ☐ ~~I am/~~ We are in possession of the above-mentioned invention.
- ☐ The ~~provisional~~/complete specification relating to the invention is filed with this application.
- ☐ ~~The invention as disclosed in the specification uses the biological material from India and the necessary permission from the competent authority shall be submitted by me/us before the grant of patent to me/us.~~
- ☐ There is no lawful ground of objection(s) to the grant of the Patent to me/us.
- ☐ ~~I am~~/we are the true & first inventor(s).
- ☐ ~~I am/we are the assignee or legal representative of true & first inventor(s).~~
- ☐ ~~The application or each of the applications, particulars of which are given in Paragraph-8, was the first application in convention country/countries in respect of my/our invention(s).~~
- ☐ ~~I/We claim the priority from the above mentioned application(s) filed in convention country/countries and state that no application for protection in respect of the invention had been made in a convention country before that date by me/us or by any person from which I/We derive the title.~~
- ☐ ~~My/our application in India is based on international application under Patent Cooperation Treaty (PCT) as mentioned in Paragraph-9.~~
- ☐ ~~The application is divided out of my /our application particulars of which is given in Paragraph-10 and pray that this application may be treated as deemed to have been filed on DD/MM/YYYY under section 16 of the Act.~~
- ☐ ~~The said invention is an improvement in or modification of the invention particulars of which are given in Paragraph-11.~~

13. FOLLOWING ARE THE ATTACHMENTS WITH THE APPLICATION

(a) Form 2

Item	Details	Fee	Remarks
Complete/ ~~Provisional~~ specification) #	No. of pages: 14		
No. of Claim(s)	No. of claims: 10 No. of pages: 02		
Abstract	No. of pages: 01		

No. of Drawing(s)	No. of drawings: 02 No. of pages: 01		

In case of a complete specification, if the applicant desires to adopt the drawings filed with his provisional specification as the drawings or part of the drawings for the complete specification under rule 13(4), the number of such pages filed with the provisional specification are required to be mentioned here.

(b) Complete specification (in conformation with the international application)/as amended before the International Preliminary Examination Authority (IPEA), as applicable (2 copies).

(c) Sequence listing in electronic form

(d) Drawings (in conformation with the international application)/as amended before the International Preliminary Examination Authority (IPEA), as applicable (2 copies).

(e) Priority document(s) or a request to retrieve the priority document(s) from DAS (Digital Access Service) if the applicant had already requested the office of first filing to make the priority document(s) available to DAS.

(f) Translation of priority document/Specification/International Search Report/International Preliminary Report on Patentability.

(g) Statement and Undertaking on Form 3

(h) Declaration of Inventorship on Form 5

(i)Power of Authority

(j)**Total fee ₹…….in Cash/ Banker's Cheque /Bank Draft bearing No..... Date on ……. Bank.**

I/We hereby declare that to the best of my/our knowledge, information and belief the fact and matters slated herein are correct and I/We request that a patent may be granted to me/us for the said invention.

Dated this 25th day of August 2023

Applicant: Andhra University

To,

The Controller of Patents

The Patent Office, at Chennai

Note: -

* Repeat boxes in case of more than one entry.
* To be signed by the applicant(s) or by authorized registered patent agent otherwise where mentioned.
* Tick ()/cross (x) whichever is applicable/not applicable in declaration in paragraph-12.
* Name of the inventor and applicant should be given in full, family name in the beginning.
* Strike out the portion which is/are not applicable.
* For fee: See First Schedule";

FORM 2

THE PATENTS ACT, 1970

(39 of 1970)

&

The Patent Rules, 2003

COMPLETE SPECIFICATION

(See section 10 and rule 13)

TITLE OF THE INVENTION

"A METHOD AND APPARATUS FOR 3D BIOMEDICAL IMAGE RECONSTRUCTION"

Applicant

NAME	**NATIONALITY**	**ADDRESS**
Andhra University	Indian	Visakhapatnam, Andhra Pradesh, India. Pin Code: 530003

The following specification particularly describes the nature of the invention and the manner in which it is performed:

FIELD OF THE INVENTION

[001] The present invention pertains to the domain of medical imaging, and more particularly, to a method and apparatus designed for the reconstruction of three-dimensional (3D) biomedical images. This system is particularly beneficial for improving the visual representation, interpretation, and analysis of complex anatomical structures, pathological entities, and physiological processes, allowing for enhanced diagnostics, treatment planning, and monitoring in the medical and clinical environment.

BACKGROUND OF THE INVENTION

[002] The following description provides the information that may be useful in understanding the present invention. It is not an admission that any of the information provided herein is prior art or relevant to the presently claimed invention, or that any publication specifically or implicitly referenced is prior art.

[003] Further, the approaches described in this section are approaches that could be pursued, but not necessarily approaches that have been previously conceived or pursued. Therefore, unless otherwise indicated, it should not be assumed that any of the approaches described in this section qualify as prior art merely by virtue of their inclusion in this section.

[004] The evolution of medical imaging has been at the forefront of clinical diagnostics, treatment planning, and biomedical research for many decades. Traditional two-dimensional (2D) imaging techniques, such as X-rays and ultrasound, have been integral in providing insights into the internal structures of the human body. However, with the inherent limitation of 2D representations, there has always been a need to visualize anatomical and pathological

structures in a more comprehensive manner, preserving the depth, orientation, and spatial relationships of the structures being examined.

[005] The advent of three-dimensional (3D) imaging technologies such as computed tomography (CT), magnetic resonance imaging (MRI), and positron emission tomography (PET) heralded a new era in medical imaging. These modalities offer 3D visualizations, providing clinicians with more volumetric information about patient anatomy and pathologies. However, raw data from these imaging techniques often come in the form of multiple 2D slices or projections, necessitating sophisticated computational methods to reconstruct them into coherent, meaningful 3D images that can be interpreted with accuracy.

[006] Yet, even with these advancements, the task of reconstructing high-quality 3D images from raw biomedical data has remained challenging. Factors like noise, artefacts, and partial volume effects can degrade the quality of the reconstructed images. Furthermore, the increasing volume of data produced by modern imaging devices demands computationally efficient algorithms that can process large datasets in reasonable timeframes without compromising on the quality of the reconstructed images. There have been various methods in the past attempting to address these challenges. Some relied on iterative reconstruction techniques, while others employed advanced filtering methods or incorporated machine learning algorithms.

[007] Despite these attempts, there remains a considerable gap in the market for a method and apparatus that can produce high-definition, accurate, and clinically relevant 3D biomedical images in a fast and efficient manner. The ideal solution would seamlessly integrate with existing imaging modalities, handle

vast amounts of data, and provide unparalleled clarity and detail in the reconstructed images. Furthermore, with the growing importance of personalized medicine and precision diagnostics, there's an increasing demand for 3D reconstruction methods that can be tailored to individual patient needs and specific clinical scenarios. This background sets the stage for the introduction of the present invention, which aims to address these needs and challenges in the realm of 3D biomedical image reconstruction.

[008] Building on the existing body of knowledge and addressing the identified challenges, the present invention emerges as a beacon of innovation in the realm of 3D biomedical image reconstruction. Recognizing the imperatives of speed, accuracy, and adaptability, the invention intertwines advanced computational algorithms, adaptive filtering techniques, and potentially, the robustness of artificial intelligence (AI) methodologies. This confluence not only ensures the rendering of clear and accurate 3D images but also anticipates the varying complexities associated with different anatomical structures and pathologies.

[009] A notable attribute of this invention is its adaptability to different imaging modalities. Whether data is sourced from MRI, CT, PET, or even newer modalities, the invention has the flexibility to tailor its reconstruction processes. By analyzing inherent characteristics of each modality and adjusting algorithms accordingly, the invention ensures optimum results across the board.

[010] Furthermore, in an era where data-driven insights are crucial, this invention goes beyond mere image reconstruction. It introduces capabilities for richer data analysis, extracting nuanced insights from the reconstructed images. Such features can play a pivotal role in advancing diagnostic precision,

offering clinicians a deeper understanding of the presented pathologies and conditions.

[011] Moreover, the computational efficiency of the proposed method cannot be overstated. Recognizing the real-world constraints of clinical settings, where time is often of the essence, this invention ensures swift processing times without compromising on image quality. This is especially crucial during surgeries or interventions where real-time or near-real-time 3D image reconstructions can guide clinicians in their procedures.

[012] Another breakthrough associated with this invention is its ability to reduce artifacts and noise. By leveraging advanced noise-reduction techniques and algorithms designed to identify and correct artifacts, the method ensures that the final 3D images are not only clear but also free from distortions that could impede accurate interpretations.

[013] Lastly, in recognizing the global trend towards personalized medicine, this invention is designed to be patient-centric. It has the capability to adjust its processes based on individual patient data, ensuring that the reconstructed images are most relevant to the individual's unique anatomy and condition. This focus on personalization enhances the utility of the invention, ensuring its relevance in diverse clinical scenarios and across varied patient populations.

SUMMARY OF THE PRESENT INVENTION

[014] The proposed invention offers an innovative method and apparatus for 3D biomedical image reconstruction, addressing long-standing challenges in the field of medical imaging. It integrates advanced computational algorithms with adaptive filtering techniques and potentially harnesses the capabilities of artificial intelligence to render clear and accurate 3D visualizations.

[015] The invention boasts adaptability across different imaging modalities, such as MRI, CT, and PET, and ensures optimal results by tailoring its reconstruction processes based on the unique characteristics of each modality. With a focus on computational efficiency, it ensures swift processing times while maintaining impeccable image quality.

[016] The system also includes advanced noise-reduction algorithms designed to minimize distortions and artifacts, resulting in clear images. A standout feature of the invention is its emphasis on personalization, adjusting its processes based on individual patient data to yield reconstructions that are most pertinent to the patient's unique anatomy and condition. This patient-centric approach ensures the invention's relevance across diverse clinical scenarios, promising to be an invaluable tool for clinicians, radiologists, and medical researchers.

[017] In this respect, before explaining at least one object of the invention in detail, it is to be understood that the invention is not limited in its application to the details of set of rules and to the arrangements of the various models set forth in the following description or illustrated in the drawings. The invention is capable of other objects and of being practiced and carried out in various ways, according to the need of that industry. Also, it is to be understood that the phraseology and terminology employed herein are for the purpose of description and should not be regarded as limiting.

[018] These together with other objects of the invention, along with the various features of novelty which characterize the invention, are pointed out with particularity in the disclosure. For a better understanding of the invention, its

operating advantages and the specific objects attained by its uses, reference should be made to the accompanying drawings and descriptive matter in which there are illustrated preferred embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[019] When considering the following thorough explanation of the present invention, it will be easier to understand it and other objects than those mentioned above will become evident. Such description refers to the illustrations in the annex, wherein:

[020] FIG. 1, illustrates a general functional working diagram, in accordance with an embodiment of the present invention.

[021] FIG. 2, illustrates a concept of the functional flow diagram, accordance with an embodiment of the present invention.in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[022] The following sections of this article will provide various embodiments of the current invention with references to the accompanying drawings, whereby the reference numbers utilised in the picture correspond to like elements throughout the description. However, this invention is not limited to the embodiment described here and may be embodied in several other ways. Instead, the embodiment is included to ensure that this disclosure is extensive and complete and that individuals of ordinary skill in the art are properly informed of the extent of the invention.

[023] Numerical values and ranges are given for many parts of the implementations discussed in the following thorough discussion. These

numbers and ranges are merely to be used as examples and are not meant to restrict the claims' applicability. A variety of materials are also recognised as fitting for certain aspects of the implementations. These materials should only be used as examples and are not meant to restrict the application of the innovation.

[024] Referring now to the drawings, these are illustrated in FIG. **1**&**2,** The invention introduces a groundbreaking method and apparatus tailored for the meticulous task of 3D biomedical image reconstruction. Delving deep into the realm of medical imaging, this novel solution understands and fills the significant void left by traditional methods that often struggle with the challenges of rendering clear, accurate, and clinically valuable three-dimensional images from two-dimensional data sets.

[025] At the core of this invention is a unique fusion of state-of-the-art computational algorithms. These algorithms have been meticulously designed and optimized to interact seamlessly with a myriad of imaging modalities, including but not limited to MRI, CT, and PET scans. This cross-modality compatibility is vital in ensuring that the reconstructed images are not just three-dimensional renderings, but they are of the utmost quality, true to the source, and are robust enough to withstand rigorous clinical scrutiny.

[026] Integral to the apparatus is the deployment of adaptive filtering techniques. Recognizing that medical images often come with their share of noise and other disturbances, this invention doesn't merely reconstruct; it refines. The adaptive filters work in real-time, identifying potential noise or artifacts in the raw data and then mitigating them in the reconstruction process.

[027] This ensures that the final rendered 3D image is of unparalleled clarity,

devoid of the typical distortions that might hamper accurate medical interpretations.

[028] Yet, what truly sets this invention apart is its pioneering use of artificial intelligence methodologies. Understanding the intricacies and nuances of biomedical images, the AI component of this invention delves deep into the data, making intricate adjustments and refinements that might elude traditional algorithms. This AI-driven approach doesn't just stop at image enhancement. It also paves the way for richer data analysis, with the potential to extract deeper insights from the images, offering a level of granularity and detail that is often elusive in conventional 3D reconstruction methods.

[029] Recognizing the critical need for speed in clinical environments, this invention is engineered for efficiency. Despite its intricate processes and the depth of its analysis, the apparatus delivers reconstructed images in impressively swift timeframes. This is pivotal, especially in surgical or interventional scenarios where real-time or near-real-time data might influence clinical decisions.

[030] Personalization, a cornerstone of modern medicine, finds its echo in this invention. Rather than offering a one-size-fits-all solution, the apparatus is intuitively designed to cater to individual patient needs. Drawing on patient-specific data, the reconstruction process can be tailored, ensuring that the rendered 3D images resonate with the unique anatomy and medical conditions of the individual, making it particularly valuable in the era of personalized medicine.

[031] Building upon its foundational capabilities, the invention also displays an intrinsic aptitude for scalability and adaptability. As medical imaging modalities

continue to evolve, generating richer, more complex datasets, the ability of this system to scale up and adapt to new data formats and types becomes crucial. Given the rapid advancements in the medical imaging field, the invention's inherent flexibility ensures its longevity and continued relevance.

[032] One of the unsung strengths of this invention is its user-friendly interface. Recognizing that the end-users are often medical professionals without deep technical knowledge, the apparatus offers a streamlined user experience. With intuitive controls and a responsive interface, clinicians can easily navigate the reconstruction process, make desired adjustments, and fine-tune the final output. This ease of use ensures that the invention integrates smoothly into clinical workflows, minimizing disruptions and steep learning curves.

[033] Beyond the realm of diagnostics, the invention's applications extend to therapeutic planning and medical research. The high-definition 3D images, combined with the deep insights extracted through the AI algorithms, provide clinicians with a holistic view of patient anatomy and pathologies. This comprehensive understanding can significantly influence treatment choices, surgical plans, and therapeutic interventions, leading to more informed and targeted care. Additionally, in the research domain, the ability to have clear 3D reconstructions can offer researchers unprecedented insights into disease progression, anatomical variations, and the effects of various interventions, potentially spearheading groundbreaking discoveries.

[034] Another noteworthy facet is the invention's potential for integration with other medical technologies. In a world moving towards augmented reality (AR) and virtual reality (VR) in medical applications, the high-quality 3D reconstructions can be used as foundational data for immersive medical

simulations, training platforms, and patient education tools. This integration can bridge the gap between advanced medical imaging and interactive, immersive experiences, further broadening the invention's impact.

[035] In conclusion , the invention represents more than just another step in 3D biomedical image reconstruction; it's a leap. By holistically addressing the myriad challenges inherent to the process and extending its applications beyond traditional boundaries, the invention stands as a testament to what is possible at the confluence of technology, medicine, and innovation. As it makes its foray into clinical and research settings, its potential to enhance patient outcomes, refine medical practices, and drive forward research is unparalleled, marking a new chapter in the annals of medical imaging.

We Claim:

1. A method for 3D biomedical image reconstruction, wherein said method incorporates computational algorithms optimized for multiple imaging modalities, including but not limited to MRI, CT, and PET scans.
2. The method as claimed in claim 1, wherein the reconstruction process employs adaptive filtering techniques to identify and mitigate potential noise or artifacts in raw imaging data.
3. The method as claimed in any of the preceding claims, further integrating artificial intelligence methodologies to enhance the quality and clarity of the reconstructed 3D images.
4. The method as claimed in any of the preceding claims, wherein the artificial intelligence methodologies facilitate deeper data analysis, extracting nuanced insights from the reconstructed images.
5. An apparatus for 3D biomedical image reconstruction, comprising processing units optimized for real-time or near-real-time rendering of three-dimensional images from two-dimensional imaging datasets.
6. The apparatus as claimed in claim 5, featuring a user interface designed to provide medical professionals with intuitive controls and feedback mechanisms for refining the reconstructed image.
7. The method as claimed in any of the preceding claims, wherein the 3D reconstruction process is personalized based on individual patient data, ensuring the images resonate with unique patient anatomy and conditions.
8. The apparatus as claimed in claim 5 or 6, designed for scalability, capable of adapting to evolving medical imaging modalities and increasing dataset complexities.

9. A system, incorporating both the method as described in claims 1 to 4 and 7 and the apparatus as described in claims 5, 6, and 8, designed for integration with augmented reality and virtual reality platforms for immersive medical experiences.

10. The method as claimed in any of the preceding claims, wherein the high-definition 3D reconstructions are employed for therapeutic planning, surgical simulations, or advanced biomedical research, offering holistic insights into patient anatomy and potential pathologies.

Dated this 25th day of August 2023

Applicant

Andhra University

ABSTRACT

A METHOD AND APPARATUS FOR 3D BIOMEDICAL IMAGE RECONSTRUCTION

[036] A method and apparatus for 3D biomedical image reconstruction, employing advanced computational algorithms, adaptive filtering techniques, and artificial intelligence methodologies. The system provides high-definition 3D reconstructions from various imaging modalities while ensuring swift processing times. The adaptive filters mitigate distortions, and the AI-driven process enhances image quality and provides deeper data analysis. With an emphasis on personalization, the invention tailors reconstructions to individual patient data, making it valuable for both clinical and research applications.

Accompanied Drawing **[FIGS. 1-2]**

Dated this 25th day of August 2023

Applicant

Andhra University

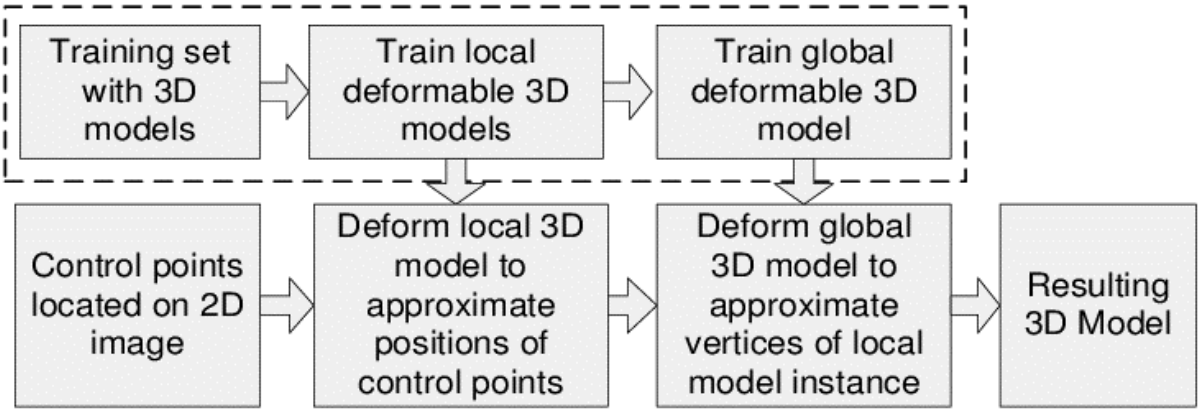

Figure 1

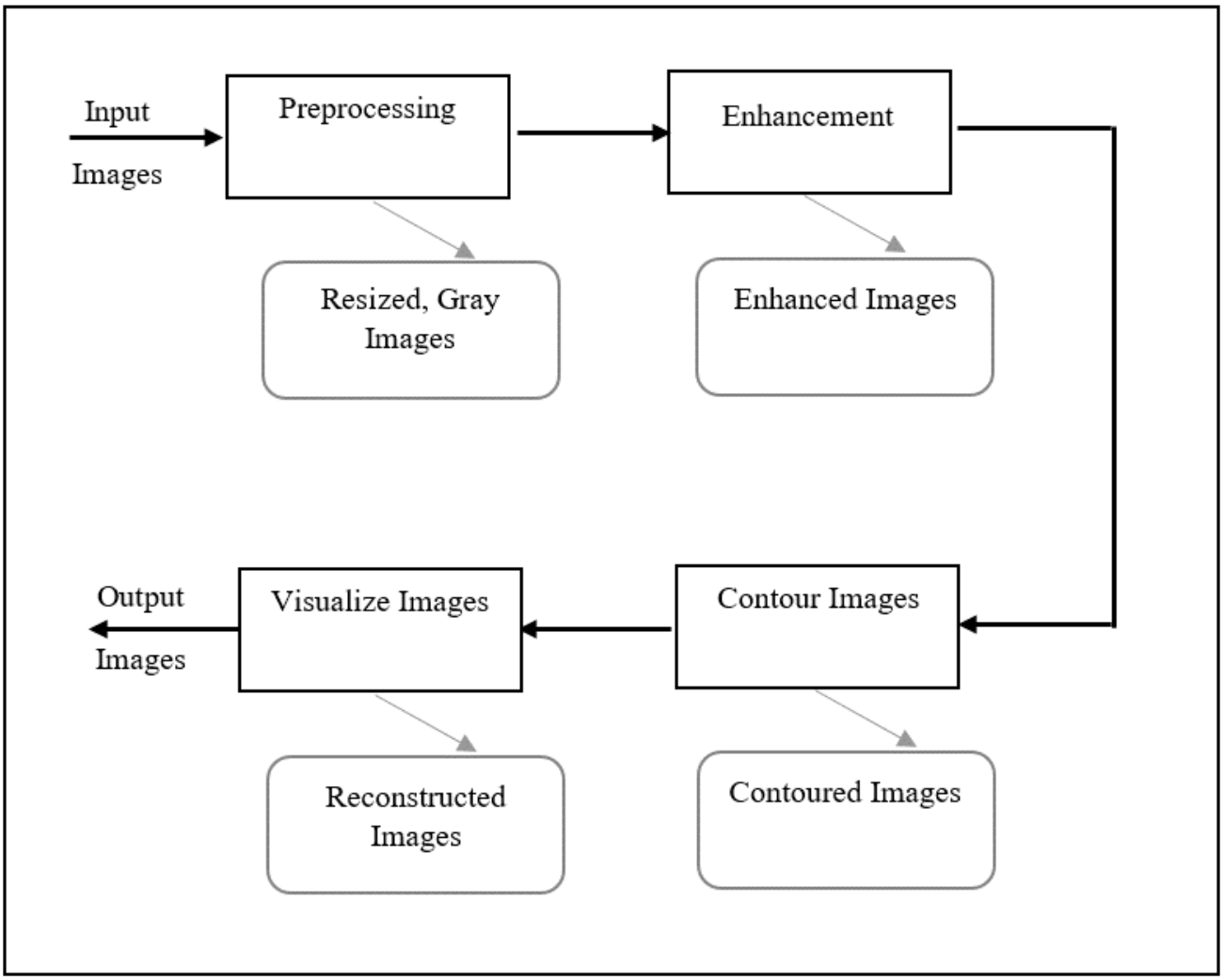

Figure 2

Dated this 25th day of August 2023