IMPLEMENTATION OF ECHOCARDIOGRAPHIC IMAGE SEGMENTATION TECHNIQUES FOR BLOOD FLOW AND VOLUME ESTIMATION.

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Abstract: - ***The Doppler Effect, which occurs on the reflection of moving blood or tissue, is observed as a shift in frequency of the reflected ultrasound. This Doppler shift has been widely used in clinical practice as a means of measuring blood velocity. Images can be produced by these devices if a narrow beam is slowly moved across a blood vessel and the blood velocity at each position displayed on a screen.***

The existing approaches for blood volume estimations are labor intensive, intricate and time consuming. Severe volume depletion leads to masked by selective vasoconstriction. Science last decade, research has brought various methods for blood volume estimation. So there is a need to implement the system that can help to give accurate estimation of blood volume in human body.

I. INTRODUCTION

In echocardiography, the technician uses a transducer which releases high-frequency sound waves to create a picture of the heart. The transducer reads the sound waves when they return, creating a map of the inside of the chest on the basis of the ways in which the sound waves change. Latest ultrasound machines are efficient of generating very high-resolution images, and it is also possible to create a three-dimensional echocardiogram which provides an even higher level of detail. 2 d echo for echocardiography.

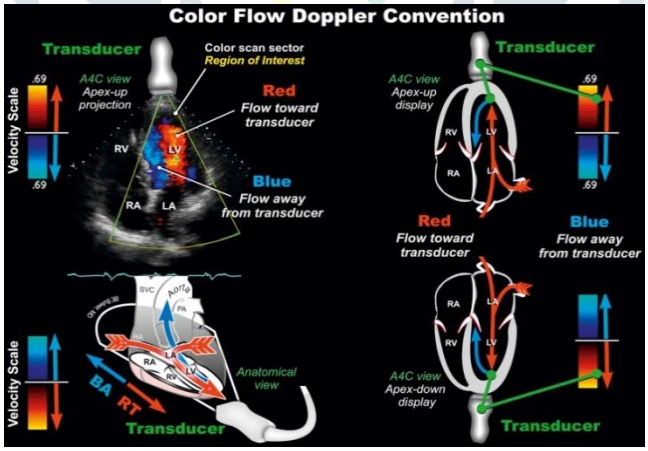

Figure: - Color Doppler Flow Convention.

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Measuring flow volume

The first volume flow estimates were made with Doppler. The ubiquitous Doppler equation is:

$$\Delta f = 2\left(\frac{v}{c}\right) f0\, cos\Theta$$

Where;

ΔF is the Doppler shifted frequency

V is the velocity of the blood flow

C is the speed of sound

F0 is the carrier frequency of the Doppler

Θ is the Doppler angle.

Solving for velocity and opening the range gate to include the entire width of a blood vessel, one can estimate the mean velocity through the range gate.

By assuming the vessel is circular in cross section, one can estimate the radius of the blood vessel, calculate the cross-sectional area of the vessel, and by multiplying flow determine the mean velocity through the cross section by the area of the cross section.

True volume flow is defined as the total flux across a surface intersecting the vessel. The flux is based on the component of the velocity normal to the intersecting plane. This is interesting in that the measurement is angle independent because of the following,

$$Volume\ flow = \oiint v \bullet ndA$$

Where;

V is the velocity of the blood flow

A small area in the surface with unit normal n, and . is the dot product.

If the Doppler frequency, Δf, at any position, is multiplied by the tipped infinitesimal area, dA where dA = dA/cos Θ

II. LITERATURE SURVEY

Central blood flow measurements are increasingly used in clinical neonatology. Its importance in clinical decision making in specific situations has been described, but some argue that its importance in clinical decision making is not sufficiently studied. However, many currently used imaging techniques and diagnostic tests in neonatal medicine (including blood pressure monitoring) have not been subjected to randomized trials to determine its efficacy on outcome. CBF measurements, as all diagnostic methods, are used to increase insight in the physiology and pathology.

Timothy A. Manzone et al. [1] provide a new semi-automated system using indicator dilution technique for blood volume analysis with highly accurate results within only 90 min. The fundamental principles off fluid balance and the clinical means of volume status assessment is given.

The widely used methods employ dye dilution and radioisotope techniques [3][15][18]. These tests are challenging to employ in daily practice as they remain invasive, labor-intensive and prone to errors. Therefore; clinicians often revert to less invasive approaches and mathematical estimates of TBV in sensitive care settings. In dilution technique TBV was calculated by hem dilution, based on the difference between the hematocrit (Hct) values from two arterial blood gas samples drawn at specific times the first was drawn 30 minutes before CPB initiation (Hct1), the second sample two minutes after the initiation of CPB (Hct2). The calculation was derived from the equation [15].

E. Pirnia et al. [5] propose a novel data-adaptive blood flow estimator exploiting transversal modulation scheme Using realistic Field II simulations. A transversal modulation scheme was introduced to induce also an oscillation along the transversal direction, thereby allowing for the measurement of also the transversal blood flow. The proposed estimator is an extension of the recent BIAA blood flow estimator, and is, as the BIAA estimator, able to form reliable estimates even for non-uniformly sampled emission schemes.

D. Vray et al. [7] developed A new speckle-variance flow processing (SFP) algorithm for noninvasive estimation of slow blood flow. This technique is based on analyzing the changes of B-mode image intensity along sequences of images. The method has been evaluated on a flow phantom with blood-mimicking fluid in the velocity range from 0.1 mm/s to 30 mm/s. The velocity index estimated with the SFP method shows a linear increase as a function of
calibrated flow velocity in the range of 0.1 mm/s to 1.5 mm/s.

L. Loevstakken et al. [8] describes the performance of a real-time implementation of blood motion imaging (BMI),using a new method for 2D blood flow visualization. It is a qualitative technique for presenting blood flow in any direction, achieved by preservation, enhancement, and display of the speckle pattern originating from the blood flow signal. Conventional methods of color flow imaging (CFI) utilize the Doppler frequency shift to estimate blood flow velocity and direction, and are therefore only sensitive to the velocity component along the ultrasound beam.

F. Karnangar et al.[9] investigated A fourth order linear finite impulse response (FIR) model of cerebral blood flow velocity (CBFV) as a function of mean arterial blood pressure (MABP) Kalman filter estimation was employed to estimate the model parameters.

Paul F. Stetson et al. [10] demonstrated that a recursive lattice filter can give correct blood velocity distribution results. The system can perform real-time processing for both the period gram and lattice-filter approaches and displays both results on a PC for comparison. Results are shown for phantom data and for demodulated data from the aorta and hepatic vein of a healthy subject. By studying this we come to know that filter gives a more realistic velocity distribution and can track rapid changes in the flow.

Aditi Kathpalia et al. [12] combined two methods i.e. the Geometric method (GM) and the Signal Noise Slope Intersection (SNSI) for Blood Flow Measurements [14]. The method enables accurate maximum velocity point detection and obtains an automated, robust tracing of the maximum velocity envelope, which can be further used for automated blood flow measurements. This technique is expected to prove useful in ultrasound machines for diagnoses by clinically inexperienced users.

A.C. Santos et al. [13] presented the estimation of coronary blood flow by computational techniques from X-ray angiography image sequences. This method is based on contrast propagation and involves artery segmentation and motion compensation. The segmentation of coronary arteries is based on the fuzzy connectedness theory and mathematical morphology.

III. PROPOSED SYSTEM

The following table represents the two columns named velocity and flow rate where velocity shows speed of the blood with the help of color bar and flow rate shows the flow of blood coming or going out of the heart. Flow Milliliter/min shows the volume of the blood in heart per min.

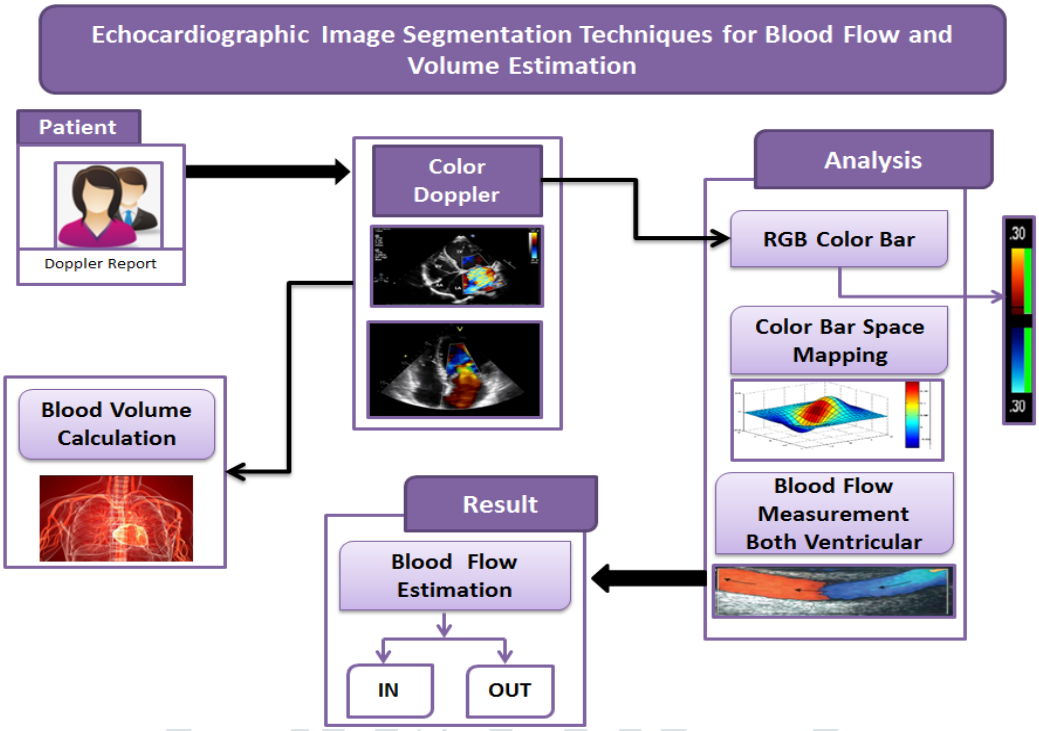


Figure: - Proposed System Architecture.

i. Load Patients Doppler Image:

Get Doppler Image of patient

ii. Blood Volume Calculation:

Blood is a complex fluid which consists of plasma and of formed elements: red blood cells, white blood cells, and platelets. The volume of blood in an average human adult is about 5 liters. Females generally have less blood volume than males. People, who live at high altitudes, where the air contains less oxygen, may have more blood than people who live in low altitude regions.

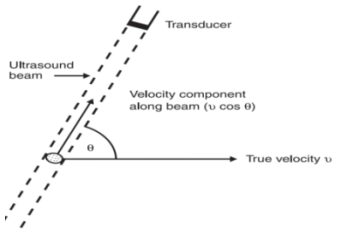
iii. Statistical Analysis:

a. Video Extraction

Video is a combination of images in sequence. FFMPEG is used to extract frames from any video format. Video frame extraction is done at 20 frames per second. Each frame is saved along with the frame number for later summary generation.

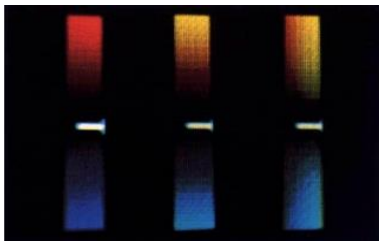
b. Color Doppler Velocity

The values of the velocity components, presented as different colors in image pixels, are therefore dependent on the angle between the true velocity direction and the beam direction at each sample volume. This angle is often not known, so care has to be taken in interpreting images since a considerable alteration in color can result from a change in angle rather than a change in velocity.



c. RGB Color Bar and Color Bar Space Mapping

Doppler color flow imaging is a method for noninvasively imaging blood flow through the heart by displaying flow data on the two-dimensional echocardiographic image. This capability has generated great excitement about the use of the technique for identifying value, congenital, and other forms of heart disease, as the color flow image imparts spatial information to the Doppler data.

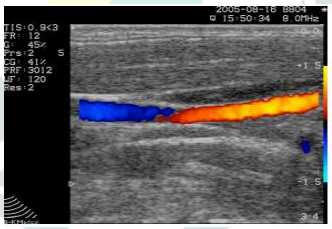


Three color bars from a color flow system. When there is no flow, black is displayed (center) in the standard bar (left), flow toward the transducer at the top is in red, flow away in blue. Progressively faster velocities are played in brighter shades of red or blue. The center bar is in an enhanced map, and the right bar in a variance map (explained later in the text).

iv. Blood Flow Measurement:

In newborn infants, CBF (Circulating blood Flow) is measured at 3 sites: right ventricular output (RVO) at the pulmonary valve, left ventricular output (LVO) at the aortic valve, and flow returning to the heart in the superior vena cava (SVC) measured at the point where the SVC starts to open up into the right atrium**.** Systemic blood flow is defined as the proportion of central blood flow directed to the organs of the body, and pulmonary blood flow as the proportion of CBF directed to the lungs. RVO has traditionally been associated with pulmonary blood flow and LVO with systemic blood flow.

v. Inference Result (Blood Flow Estimation):



The above figure illustrated the blood flow in the jugular vein that carries the blood from the brain back to the heart. Even though the volume flow in the vein is constant throughout the image, different colors appear along the vessel, and at the center of the image the scanner fails to detect any blood flow at all.

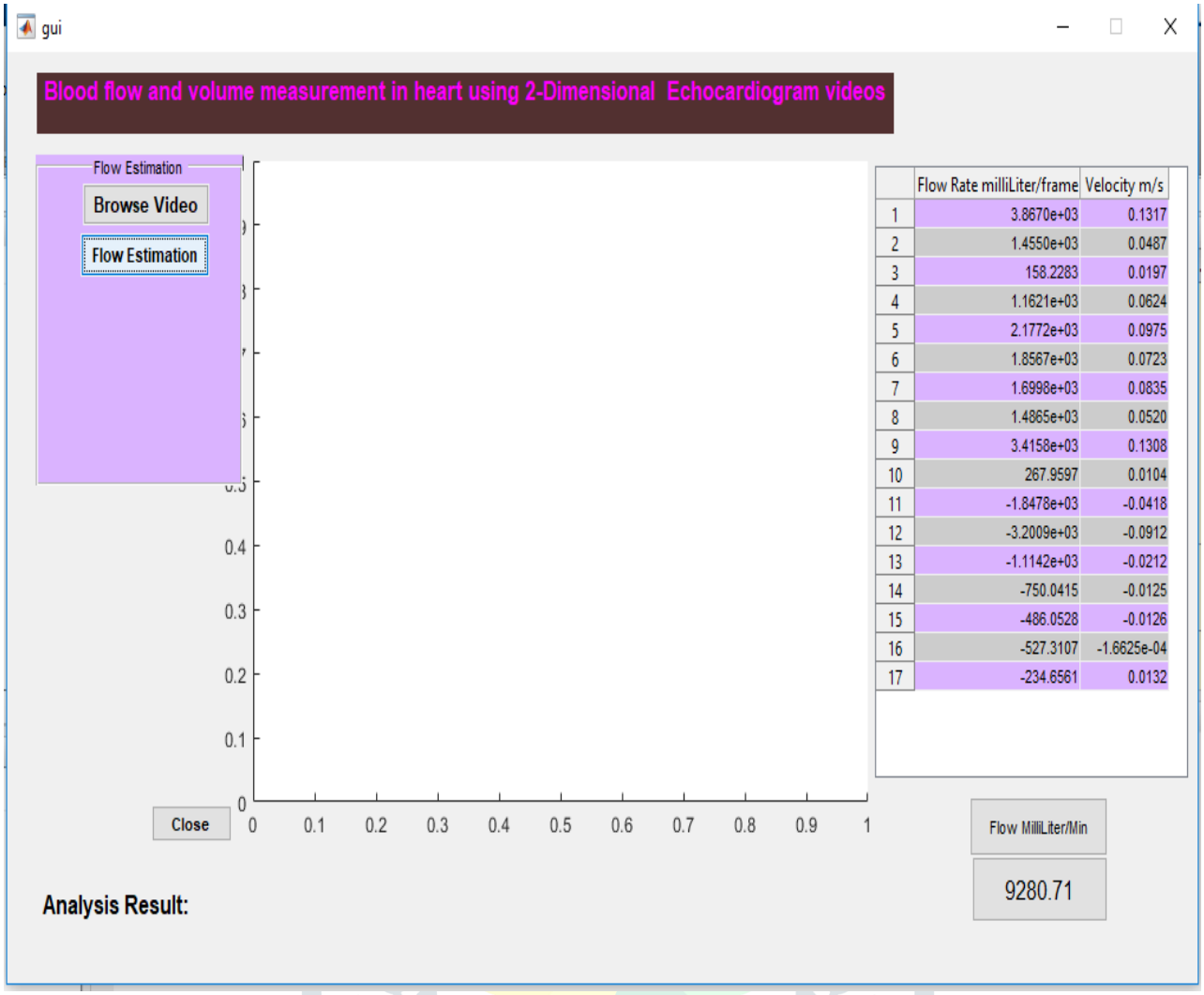
IV. RESULTS AND DISCUSSION:-

The following table represents the two columns named velocity and flow rate where velocity shows speed of the blood with the help of color bar and flow rate shows the flow of blood coming or going out of the heart. Flow Milliliter/min shows the volume of the blood in heart per min.

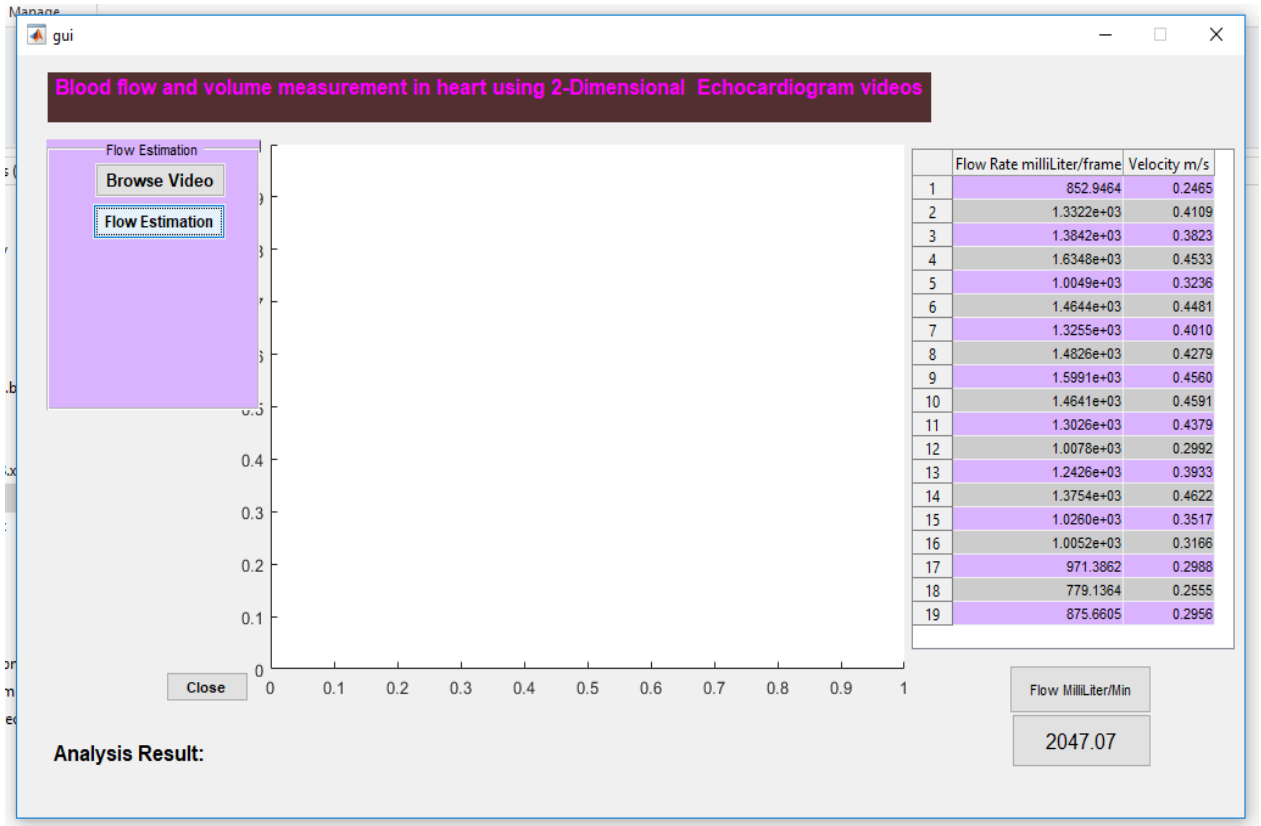
Table: - Velocity and Flow Rate

Sr No.	Flow Rate Milliliter/ Frame	Velocity (m/s)
1.	852.9464	0.2465
2.	1.3322e+03	0.4109
3.	1.3842e+03	0.3823
4.	1.6348e+03	0.4533
5.	1.0049e+03	0.3236
6.	1.4644e+03	0.4481
7.	1.3255e+03	0.4010
8.	1.4826e+03	0.4279
9.	1.5991e+03	0.4560
10.	1.4641e+03	0.4591
11.	1.3026e+03	0.4379
12.	1.0078e+03	0.2992
13	1.2426e+03	0.3933
14.	1.3754e+03	0.4622
15.	1.0260e+03	0.3517
16.	1.0052e+03	0.3166
17.	971.3862	0.2988
18.	779.1364	0.2555
19.	875.6605	0.2956

V. SCREENSHOOTS



	Flow Rate milliLiter/frame	Velocity m/s
1	3.8670e+03	0.1317
2	1.4550e+03	0.0487
3	158.2283	0.0197
4	1.1621e+03	0.0624
5	2.1772e+03	0.0975
6	1.8567e+03	0.0723
7	1.6998e+03	0.0835
8	1.4865e+03	0.0520
9	3.4158e+03	0.1308
10	267.9597	0.0104
11	-1.8478e+03	-0.0418
12	-3.2009e+03	-0.0912
13	-1.1142e+03	-0.0212
14	-750.0415	-0.0125
15	-486.0528	-0.0126
16	-527.3107	-1.6625e-04
17	-234.6561	0.0132



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VII. CONCLUSION

Assessment of total blood volume (TBV) is central to the management of patients undergoing cardiac surgery and Cardiopulmonary bypass (CPB). TBV assessment helps to anticipate hem dilution on CPB, guides rational use of crystalloids, autologous blood prime and transfusion of blood products and helps the multidisciplinary care team anticipate potential hemodynamic instability.

This system presents techniques to estimate the blood volume. The blood volume estimation methods which is easy, quick, can be done in clinical settings and repeatable. The main objective of our research studies is the elaboration of an existing optical system for measuring blood volume in the Para corporeal pneumatic, pulsatile ventricular assist devices. By studying all the techniques we come to know that there is the need for a precise framework for blood flow analysis. The determination of clinically relevant parameters to assess the blood flow, to support clinical trial and validation. To support the cooperation between medical doctors and investigators in research and development of cardiovascular signal processing applications.

REFERENCES

[1] Timothy A. Manzone1, Hung Q. Dam1,2, Daniel Soltis3, and Vidya V. Sagar,"Blood Volume Analysis: A New Technique and New Clinical Interest Reinvigorate a Classic Study".

[2] Ryosuke Murakia, Arudo Hiraokab, Kazuyuki Nagataa, Kosuke Nakajimaa, Tomoya Oshitaa, Masahisa Arimichia,Genta Chikazawab, Hidenori Yoshitakaband Taichi Sakaguchi,"Novel method for estimating the total blood volume: the importanceof adjustment using the ideal body weight and age for the accurateprediction of haemodilution during cardiopulmonary ypass"2018. Published by Oxford University.

[3] Prathap Moothamadathil Baby, Pramod Kumar, Rajesh Kumar, Sanu S. Jacob, Dinesh Rawat, V. S. Binu, and Kalesh M. Karun A novel method for blood volume estimation using trivalent chromium in rabbit models, www.researchgate.net/publication/265393379.

[4] J. G. Jones and C. A. J. Wardrop,"Measurement of blood volume in surgical andintensive care practice", The Board of Management and Trustees of the British Journal of Anaesthesia 2000.

[5] E. Pirnia, A. Jakobsson, E. Gudmundson,, and J. A. Jensen,"DATA ADAPTIVE ESTIMATION OF TRANSVERSAL BLOOD FLOW VELOCITIES",2014 IEEE International Conference on Acoustic, Speech and Signal Processing (ICASSP).

[6] Jonathan Pore ; Thomas Deffieux ; Mathieu Pernot ; Charlie Demene ; Jerome Baranger ; Mickael Tanter ,"High-resolution vector Doppler for cerebral blood flow estimation", 2017 IEEE International Ultrasonics Symposium (IUS).

[7] D. Vray ; A. Needles ; V.X.D. Yang ; F.S. Foster ,"High frequency B-mode ultrasound blood flow estimation in the microvasculature", IEEE Ultrasonics Symposium, 2004.

[8] L. Loevstakken ; S. Bjaerum ; D. Martens ; H. Torp ,"Real-time blood motion imaging a 2D blood flow visualization technique", IEEE Ultrasonic Symposium, 2004.

[9] F. Karnangar ; M.A. Masnadi-Shirazi ; K. Behbehani ; R. Zhang ; N. Nazeran ; B.D. Levine ,"A model of cerebral blood flow velocity as a function of mean arterial blood pressure using Kalman filter estimation techniques", Proceedings of the Second Joint 24th Annual Conference and the Annual Fall Meeting of the Biomedical Engineering Society] [Engineering in Medicine and Biology.

[10] Paul F. Stetson and Jcirgen Arendt Jensen, "Real-Time Blood Flow Estimation Using a Recursive Least-Squares Lattice Filte",IEEE 1997.

[11] Dimple Modgil ; David S. Rigie ; Michael D. Bindschadler ; Adam M. Alessio ; Patrick J. La Rivire ,"Vectorial total variation denoising for myocardial blood flow estimation in dynamic CT", 2014 IEEE Nuclear Science Symposium and Medical Imaging Conference (NSS/MIC).

[12] Aditi Kathpalia1, Ycel Karabiyik1, Bente Simensen2, Eva Tegnander2,3, Sturla EikNes2,3, Hans Torp1, Ingvild Kinn Ekroll1, Gabriel Kiss1,"A Robust Doppler Spectral Envelope Detection Technique for Automated Blood Flow Measurements ",2015 IEEE.

[13] A.C. Santos ; S.S. Furuie ,"Estimation of coronary blood flow by contrast propagation using X-ray cineangio graphic images", Computers in Cardiology 2001. Vol.28 (Cat. No.01CH37287).

[14] K. Marasek and A. Nowicki, "Comparison of the performance of three maximum Doppler frequency estimators coupled with different spectral estimation methods.," Ultrasound Med. Biol., vol. 20, no. 7, pp. 629-638, 1994.

[15] JN Hilberath,1 ME Thomas,2 T Smith,3 C Jara,4 DJ Fitzgerald,3 K Wilusz,1 X Liu,1 and JD Muehlschlegel1"Blood volume measurement by hemodilution: association with valve disease and re-evaluation of the Allen Formula" ,June 24, 2015.

[16] http://www.cpdsolutions.co.za/Publications/article uploads/Cardiology ultrasound.pdf.

[17] M. Kluckow and N. Evans, “Superior vena cava flow in newborn infants: a novel marker of systemic blood flow,” Archives of Disease in Childhood: Fetal and Neonatal Edition, vol. 82, no. 3, pp. F182–F187, 2000.

[18] ROBERT H. EICH, M.D., WILLIAM R. CIIAFFEE, M.D., AND ROBERT B. CHODOS, M.D, "Measurement of Central Blood Volume by External Monitoring",Circulation Research, Volume IX, May 1SS1.