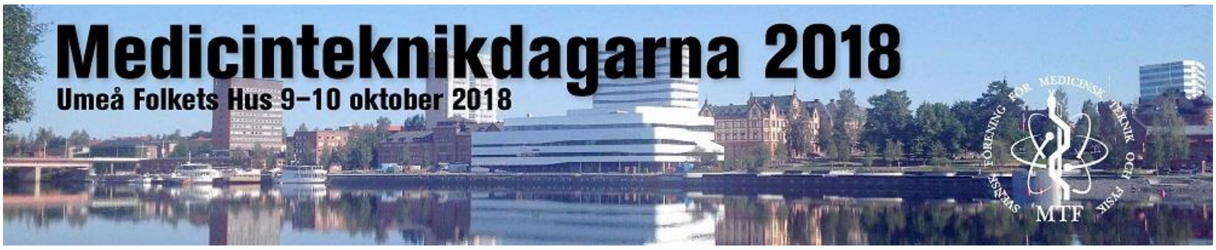


MEDICINSK TEKNIK INOM KARDIOLOGI

Tisdag 9 oktober 11.20 – 12.20

Abstract: 156

Carotid artery wall composition based on ultrasound – Comparison between different stages of atherosclerotic burden and Deep learning approach

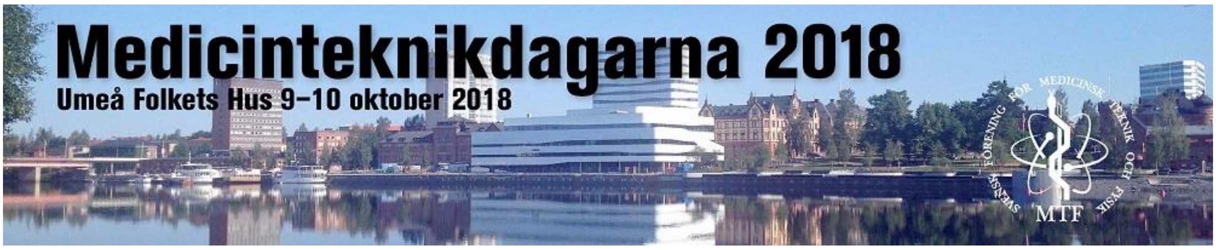
**E. Nyman*1, E. Rodin Ericson1, J. Vesterlind2, J.C. Nieves2, C. Grönlund3; 1Umeå University, Public Health and Clinical Medicine, Umeå, 2Umeå University, Computer science, Umeå, 3Umeå University, Radiation Sciences, Biomedical Engineering R&D, Umeå*

Background:
Despite decades of research in the field of cardiovascular diseases (CVD), current risk prediction models fail to identify all high-risk individuals, and for many, sudden death can be the first manifestation of the disease. This dilemma challenges health care and initiates the need for additional risk markers. Atherosclerosis is the main cause of CVD and with carotid artery B-mode ultrasound the degree of atherosclerotic burden can be measured. The intima media thickness (IMT) have shown to correlate with an increased risk for CVD and are suggested as an additional risk marker for CVD. Beside the IMT measurement, the composition, echo structure, of the intima-media complex (IMc) is a new region of interest in the assessment of atherosclerosis. Development of new computer assisted methods could have a potential role in future primary prevention models. There is to our knowledge no current study measuring IMc echo structure and its correlation to different stages of atherosclerotic burden.

Material & Methods:
From the population based cohort study VIPVIZA (n:3600) three subgroups were selected based on the amount of atherosclerosis identified by carotid artery ultrasound as I) Ordinary (IMT <50e percentile, no carotid plaques; II) Intermediated atherosclerotic burden (IMT >50e - 75e percentile, no carotid plaques) III) Pronounced atherosclerotic burden (IMT >75e percentile and bilateral carotid plaque presence). An in-house computer software automatically extracted the IMc region of interests from standard carotid longitudinal B-mode images, and computed traditional risk markers e.g. Gray Scale median (GMS), Coarseness and size. Comparisons were made between the subgroups based on atherosclerotic burden and the IMc risk markers. For the deep learning approach, three CNN architectures, LeNet, VGG16 and VGG19, were used to train on the extracted IMc images.

Result:
The computer assisted software based on the ultrasound scans identified 592, 620, 592 participants in the ordinary, intermediated and pronouncing subgroups respectively. There was a significantly difference (p:<0.001) between the three subgroups in the risk markers. Increased atherosclerotic burden showed increased heterogeneity and size of the IMc. Further, despite subgroup we found that the IMc heterogeneity and size correlated with age and sex, were elderly (age >60 years) and males had significantly (p<0.001) increased heterogeneity and size compared with younger individuals and females. In addition, the trained Deep Learning methods showed that the LeNet architecture had the best classification performance with an accuracy at 70%.

Conclusion:
Traditional ultrasound based risk markers were significantly different in the different stages of the atherosclerotic disease, and Deep Learning techniques showed promising results. The proposed methods have potential for future risk prediction measurements.



Abstract: 103

Image-Driven High Performance Computing in Biomedical Engineering for Diagnosis & Intervention Planning

M. Karlsson[1], M. Andersson[1], J. Lantz[2], A. Persson[3], T. Ebbers[2]; [1]Linköping University, Department of Management and Engineering, Linköping, [2]Linköping University, Department of Medicine and Care, Linköping, [3]Linköping University, CMIV, Linköping

Creating models of the human cardiovascular system has been a goal in biomedical engineering for decades, ever since the very first computers were made available; while the modeling behavior and responses itself is a tremendous challenge, creating simulation models capable of predicting the outcome of interventions and/or merely indicating long-term trends - in a clinically relevant timespan - has until now remained a vision.

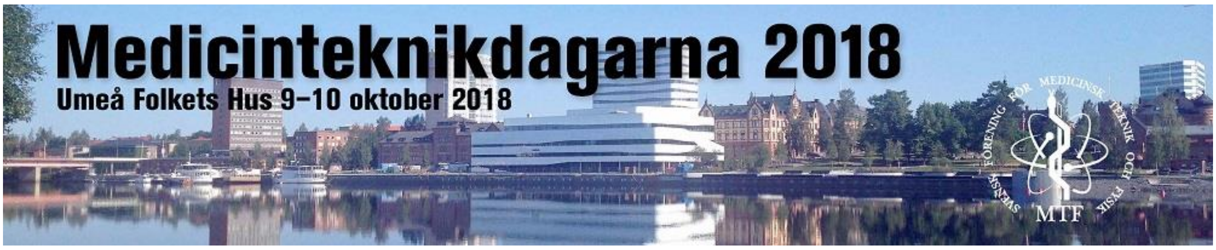
The development has until recently been hampered by the limited spatial resolution of imaging techniques, and the fact that segmentation of image data to construct the geometries is difficult, cumbersome and often requires a highly trained specialist. Furthermore, even if a model can be derived, the questions still remains whether this model is resembling the flow of the specific patient. With the introduction of different imaging techniques such as CT, MRI and 3D ultrasound it is now possible to make very precise 3D geometrical depictions of a specific patient´s heart and vascular system. With such very detailed geometrical models there is a short step towards performing computer simulations, either with fixed or moving walls.

These novel imaging techniques are also capable of measuring other information, like velocity and turbulent intensity in 4D, making it possible to develop image-based clinically applicable tools for simulation of cardiovascular hemodynamics. Here we demonstrate the feasibility and fidelity of cardiac as well as vascular flow simulations using CFD to create site-specific numerical models of arterial flow and blood flow in the heart in order to aid in diagnostic decisions, intervention planning as well as follow-up studies in two different examples.

Cardiac blood flow was simulated using computational fluid dynamics (CFD) combined with geometrical information from CT. This was also compared to in vivo flow measurements by 4D Flow MRI. Geometry and heart wall motion were obtained from clinical computed tomography measurements, with 0.3x0.3x0.3 mm spatial resolution and 20 time frames covering one heartbeat.

Turbulence in a aortic coarctation restenosis was computed using large eddy simulation (LES), using patient-specific MRI data and CFD. The domain was discretized by 6 million elements and simulated over 50 cardiac cycle to converge the phase-averaged statistics. Both qualitative and quantitative results agreed well with the 4D Flow MRI measurements.

The combination of high performance computing and state-of-the-art imaging techniques enables “what if” scenarios, including optimization of valve replacement, surgical vascular intervention as well as other procedures.



Abstract: 69

Cyclic components in arterial plaque ultrasound image sequences with unobserved components analysis

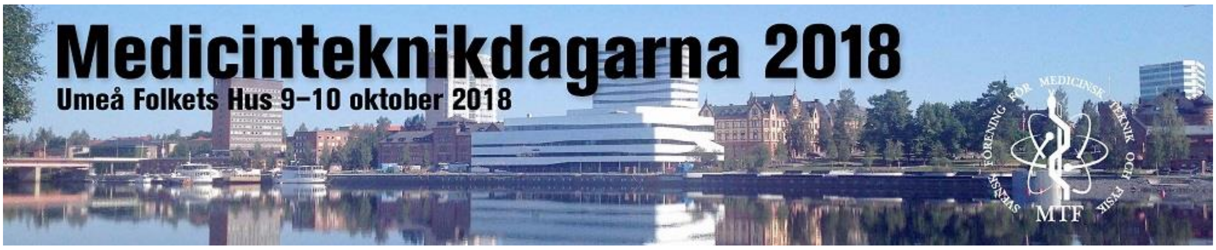
**B. Jiang*1, C. Grönlund2; 1Umeå University, Radiation Sciences, Umeå, 2Norrlands universitetssjukhus, Umeå*

Background
The arterial wall and plaque move periodically due to the changes in blood pressure and flow during the cardiac cycle. With the development of atherosclerosis, the artery wall becomes stiffer and the plaque might rupture leading to a stroke. The plaque motion provides important information regarding plaque deformation and feature extraction to distinguish whether it is vulnerable or not. Little work has been done to analyze the time series structure (trend and cycle components) in the ultrasound motion mode (M-mode) image. It was found that the plaque texture features such as gray-scale median GSM varies throughout the cardiac cycle. Recently, time series analysis for ultrasound image sequences has regained attention with the development of statistical analysis techniques, like the dynamic linear modeling (DLM). In this paper, the unobserved component model (UCM) was proposed to analyze the cyclic components of the plaque, for seeking of new relevant information about the plaque vulnerability (probability to rupture and lead to a stroke).

Methods
Unobserved Components Model (UCM) performs a time series decomposition into several unobservable components: the trend, the seasonal, the cycle component, etc. The cyclic component captures the cyclical effects when the data exhibit rises and falls that are not of a fixed period. In this paper, a cyclic frequency bounded UCM method (UCM-CB) was proposed.

Results
One of the DICOM B-mode image sequences were acquired using the Philips ultrasound system. The UCM models were computed using the open source statistical modeling package: Statsmodels. The heart rate of the patient was measured with ECG as 86 BPM (Beats per minute), and the frame rate of the image sequences is 33 fps (frames per second), so the cardiac cycle period is about frames. Thus, the bound of the cycle period was set to , and the frequency . The results show that the cyclic component can be optimally tracked, and the figure of the cycle component pattern demonstrates that different periodicities (phase inconsistency) appear at different parts of the plaque, which can’t be observed by the traditional Fourier method or the bandpass filtering method.

Conclusions
Cyclic components analysis is important in medical ultrasound, it gives relevance to the plaque’s vulnerability. To analyze the cyclic components in the carotid arterial image sequences, the cyclic frequency bounded unobserved component model (UCM-CB) method was proposed. The results have shown that the proposed UCM-CB method can effectively discriminate the cycle components between different plaque compositions. As a result, it could be a potential risk marker in cardiovascular atherosclerotic diagnoses.



Abstract: 86

Träningsredskap för venpunktion

*M. Arkenius1, A. Bengtsson1, *S. Sjöstrand*1, M. Troeng2, T. Jansson3; 1Lunds University, Biomedical Engineering, Lund, 2Lunds University Hospital, Hematology Department, Lund, 3Lund University, Clinical Sciences/Biomedical Engineering, Lund*

Venpunktion i syfte att sätta perifer venkateter, PVK, eller att ta blodprov är idag den mest genomförda proceduren inom sjukvården, både i Sverige och i resten av världen. Vid misslyckad venpunktion kan testresultat och viktig behandling försenas. Lyckad venpunktion är av yttersta vikt vid behandling av patienter inom akutsjukvården, där upp till 90% av patienterna är i behov av en perifer venkateter och livsviktig behandling inte får försenas. Det faktum att 23% av försöken till insättning av PVK misslyckas, kan innebära extra resursåtgång i form av tid och personal, men även onödigt lidande för patienten. Frekvensen av lyckade venpunktioner är starkt beroende av vårdpersonalens färdighet. Personalens färdighet är i sin tur beroende av den praktiska träning som genomförs under utbildningen. Den träningsutrustning som finns och används idag har tyvärr många brister. De scenarion som kan återskapas med dagens utrustning är få och väldigt simpla, och ger inte verklighetstrogen träning. Dessutom är träningsutrustningen dyr, vilket gör att tillräcklig praktisk träning bortprioriteras från utbildningen. Detta resulterar i att nyutbildad personal inte har fått färdighet i det de faktiskt står inför i sin yrkesroll.

Det finns därför ett behov av en ny typ av träningsmodell, där fler och svårare situationer kan simuleras, till ett pris som tillåter frekventa träningsmöjligheter i både utbildning och klinik. En första prototyp av en sådan träningsmodell har tagits fram under ett kandidatarbete på Lunds Tekniska Högskola. Träningsmodellen består av en vävnadsliknande polymer, Styren-Etylen-Butylen-Styren, SEBS. Denna polymer gjuts i en form och tre slangar placeras parallellt i modellen för att bygga en fantom med tre versioner av underarmens anatomi. Slangarna i modellen är utbytbara för att erbjuda träning på varierande kärlegenskaper såsom diameter och styvhet, och för att ersättas efter slitage. Slangarna är placerade på plattor, som även de är utbytbara. Olika former på dessa plattor simulerar olika scenarier, exempelvis rullande kärl. Tack vare att komponenterna i modellen är utbytbara och har olika egenskaper, kan användaren själv bygga upp den situation som träningen ska ske på. Ovanpå slangarna placeras ett tunt lager av den vävnadsliknande polymeren, SEBS, för att efterlikna huden. Tjockleken på dessa lager kan varieras, vilket tillåter träning på kärl som är placerade på olika djup.

Vid träning på denna modell är det bara detta tunna lager av polymeren som påverkas av nålsticket. Polymeren är till viss del självläkande, men efter en tids användning behöver det bytas ut. Materialet kan återanvändas och återskapas enkelt genom att värmas upp till 130 grader. Den vävnadsliknande polymeren är genomskinlig och tack vare detta kan användaren få visuell feedback under träningen, vilket är ett bra första steg i den praktiska träningen eller vid träning på en ny situation.

Materialet går även att färga, varvid visuell feedback uteblir, vilket möjliggör träning med ökad svårighetsgrad. Träning med denna typ av modell skulle öka vårdpersonalens färdighet, vilket sparar tid och minskar lidandet för patienterna. I det långa loppet skulle detta leda till att den mest genomförda proceduren inom sjukvården inte längre behöver vara en belastning, vare sig för patienter eller anställda.