1. BACKGROUND

Current system concepts for non-invasive monitoring of vital signs are limited in providing estimates for blood pressure, ECG, pulse oxymetry and tympanic core temperature. Although this information is considered to be sufficient in most emergency and search and rescue operations, the lack of accuracy of these vital signs measurements makes the relevant system concepts unattractive to medical practitioners.

For the specific case of monitoring the blood pressure, the traditional system concepts are based on the oscillometric technique rather than the auscultatory method that monitors the sounds as blood flows through the brachial artery (i.e. Korotkoff sounds) in the same way as the medical practitioner employs a stethoscope along with a mercury sphygmomanometer. In noisy and vibration intensive environments the pressure fluctuations caused by these disturbances are sizable compared to the pressure fluctuations that need to be detected for the proper operation of the technique, thereby reducing the accuracy. Furthermore, in noisy environments, such as onboard (or near) a rescue helicopter or ambulance, the environmental noise frequently overwhelms the acoustic signal of interest, making it impossible to make a measurement using the conventional auscultatory method.

2. SYSTEM CONCEPT AND IMPLEMENTATION

Canamet Corporation has overcome these issues by using adaptive signal processing techniques that include adaptive interference cancellation, band pass filtering, and peak discrimination (pattern recognition) algorithms.[1,2]. The use of these advanced signal processing techniques leads to a feasible system for providing vital sign measurements in challenging noisy environments, such as ambulances and helicopters. The block diagram in Figure 1 shows the block diagram layout for the blood pressure measurement system. More specifically, Canamet’s Piesometer MK-1 portable blood pressure monitor has a primary acoustic sensor integrated with the cuff and placed on the brachial artery to collect the Korotkoff sounds and any environmental noise. A secondary acoustic sensor (on the back of the patient’s arm) collects only the environmental noise, as shown in Figure 1. The adaptive interference cancellation algorithm is a non-linear filter that removes the interference measured by the secondary sensor from the desired signal received by the primary sensor that was corrupted by environmental noise. The band pass filter removes any noise outside the frequency of interest. Finally, the peak discrimination algorithm extracts valid peaks from the Korotkoff sounds in the acoustic signal that result from heartbeats. Peaks that do not satisfy these constraints are discarded; however a degree of arrhythmia is accounted for during this process. In summary, Canamet’s Piesometer MK-1 system is based the auscultatory technique that emulates the operations of the medical practitioner using the mercury sphygmomanometer and the stethoscope. This system has proven with clinical trials to have accuracy equivalent to that of a medical practitioner for patients at resting position [1,2].

![Fig 1: System Concept of Adaptive Noise Cancellation for Blood Pressure Systems based on the auscultatory method](image-url)
requirement to include into the system’s architecture a real
time clock, microcontrollers, I/O analog/digital peripherals,
telemedicine functionality through serial port/USB and
graphic interfaces for user friendly operations, makes the
existing floating point DSP processors not very attractive
for this kind of advanced and portable medical system
applications. An ideal DSP processor architecture should
include all the above peripherals and functionalities.
Canamet’s Adaptive blood pressure system is designed to be
part of an open system. This type of open system design is
shown in Figure 2. It allows for the integration of a number
of modular designs into the complete system, based on
need.
An addition to the system shown in Figure 2 is the non-
invasive monitoring of the density variations of the brain
due to changes of temperature or pressure, stroke, heat
stroke, head injuries, hemorrhage, variations of blood flow
in the skull due to drug effects, variations in metabolism and
stress [3]. This is a new system innovation, called
intracranial ultrasound technology. The design of this
system mirrors the design of the blood pressure monitoring
system as a monitoring intracranial vital signs system.
Furthermore, a portable 3D ultrasound system technology
[4,5] can be integrated as a modular unit into the above open
system design.

3 CONCLUSION
This article describes the evolution of innovative new
acoustic signal processing algorithms and DSP architectures
implemented in a wide variety of new medical electronics
applications that form the EMERGING TRENDS IN THE
FIELD OF NON-INVASIVE MEDICAL DIAGNOSTIC
TECHNOLOGIES.
The advance signal processing structure of the present
development and its implementation into a system
computing architecture has demonstrated successful
performance in obtaining:
• Blood Pressure Monitoring of systolic - diastolic
  pressure in noise intense environments, such as
  helicopters, ambulances, emergency rooms, etc.
• Implementation of an open system architecture
  with a common system bus to allow the design through
  a generic system design.
• Non-invasive monitoring of the density variations
  of the brain due by intracranial ultrasound technology.
• Continuous 24-hour monitoring of vital signs, such
  as pulse oxymetry, six-electrode (vector) ECG with
  high sampling rate (1KHz) to allow diagnosis of a wide
  spectrum heart diseases, tympanic ear thermometer.
It is anticipated that the present development would address
most of the medical requirements for non-invasive
monitoring of vital signs for Home Care, in Hospital
Emergency Departments, Ambulances, Hospital Intensive &
After Care, and applications for Family Medical Clinics,
Insurances and Old-Age Nursing Homes.

REFERENCES
[1] Pinto L., Dhanantwari A., Wong W. and
Stergiopoulos S., “Blood Pressure Measurements in Noise
Intense Environments Using Adaptive Interference
[2] Stergios Stergiopoulos and Amar Dhanantwari,
“Method and Device for Measuring Systolic and Diastolic
Blood Pressure and Heart Rate in an Environment with
Extreme Levels of Noise and Vibrations”, US Patent
6,520,918, issued 18 February 2003.
[3] Stergiopoulos S. and Wrobel M. "Non-Invasive
Diagnostic Ultrasound System Monitoring Brain
Abnormalities", US Patent application (DND File No. 1416-
01/007 USA), Dec-2001.
Bertora, P. Pellegretti, A. Questa, "An efficient 3D
beamformer implementation for real-time 4D ultrasound
systems deploying planar array probes", Proceedings of the
IEEE UFFC’04 Symposium, Montreal, Canada, Aug 2004.
Resolution 3D Ultrasound Imaging System Deploying A
Multi-Dimensional Array of Sensors and Method for Multi-
Dimensional Beamforming Sensor Signals”, United States

Fig. 2: Canamet’s Open Modular System Design for
Monitoring Vital Signs.