BIOMEDICAL ECVT
ELECTRICAL CAPACITANCE VOLUME TOMOGRAPHY

FOR BRAIN & BREAST IMAGING

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Tomography as Leading Medical Imaging Modality

Tomography is a technique used to produce a ‘slicing’ image of cross-sections of an object through image reconstruction from signal data of numerous sensors located on the surface of the object at different angles. Hospitals need different types of tomography imaging systems to differentiate illness from healthy tissues for diagnostic purposes. There are various numbers of tomography modalities based on the sensor used ranging from electromagnetic emission, ultrasound to electrical properties measurement. Most common examples of tomography techniques are Computed Tomography (CT-Scan), Magnetic Resonance Imaging (MRI) and Positron Emission Tomography (PET).

TOP: Combined PET-CT image visualizes physiological function of the human body; the image shows cancer mass developments on the right breast with bone metastasizes (bright spots); normal physiologic activities showed in the heart and both kidneys.

LEFT: MRI machine and MRI image of the human brain
Principles of ECVT

Electrical Capacitance Volume Tomography (ECVT) utilizes soft field nature of the so-called ‘fringing effect’ of electric field that distributes in 3-dimensional space. The fringing effect contains valuable information that can be extracted using soft-computing algorithm for imaging purposes with the low level energy source.

The Principles of ECVT comprises two steps: 1. Measuring capacitance between a pair of capacitive electrodes arranged in such a way to enclose a 3D sensing domain; 2. Reconstructing volumetric permittivity distribution within the 3D sensing domain from the measured capacitance using a certain algorithm.

Electrical field distribution driven by source and sink electrodes

**RIGHT:** ECVT system consists of sensor system, data acquisition system and computer system for control, image reconstruction and display

**STEP 1:** Capacitance measurement

**STEP 2:** Reconstructing 3D permittivity distribution.

PATENTS: US PTO 6577700 (Warsito & Fan, 2003); PCT, WO 2006/102388 (Warsito et al., 2006)
Breast ECVT

**WORLD’S FIRST**

4D Breast Cancer Scanner

ECVT requires only seconds to scan whole breast to find abnormalities within the breast caused by malignant cancers, benign tumors or simple cysts without performing biopsy.

LEFT: Breast ECVT provides volumetric image of the breast along with pixel values for quantitative analysis.
The ECVT differentiates malignant breast cancers from benign tumors and simple cysts based on differences in the permittivity value of the reconstructed images. The study shows a demarcation value of maximum normalized permittivity which is regarded as Cell Electrical Activity Index (CEAI) or MALIGNANCY INDEX of 0.3 to classify the malignant cancers from benign tumors and simple cysts. The ECVT is more sensitive to detect malignant cancer than simple cysts or benign tumors.
Breast ECVT: Physiological Imaging of Breast

ECVT images of the breast as compared with mammogram for malignant cancer and benign tumors.

ECVT images of breast tumors show physiological abnormality of the electrical activity generated by the tumor, in conformity with FDG activity in the image of PET—CT.
ECVT Brain Scanner offers a low-cost, radiation-free, instantaneous detection of physiological abnormalities in the brain caused by tumors, epilepsy, Alzheimer's Disease and other brain dysfunctions.

**RIGHT:** ECVT volumetric image of the brain with tumor as compared with corresponding MRI image. The Brain ECVT also detects brain activity dysfunction caused by the tumor.

Weak electrical activity corresponding to weak motoric function affected by the tumor.
Brain ECVT for Brain Function Studies

ECVT has been successfully applied to monitor activity of human brain during different stimulations. Electrical signals measured from capacitance electrodes showed significant differences when the brain is in rest and in high task. The ECVT generates real time and volumetric image of the human brain during the activity. The system helps scientists to study the human brain activity, and possibly detect abnormalities in the human brain.

**TOP:** Snapshot of real-time volumetric images of human brain activity during stimulations

**RIGHT:** Electrical signal monitoring of human brain during different stimulations
Detecting Brain Dysfunction from Brain ECVT Image

TOP: ECVT image of normal brain activity showing high electrical activity on the whole cortical surface of the brain; LOWER RIGHT: ECVT image of abnormal brain activity of a patient suffered from brain tumor indicated by the MRI image (LOWER LEFT); the ECVT image is showing low electrical activities of the brain on both the left (especially) and right frontal regions of the brain that are mainly related to visual functions, and both right (especially) and left cerebellum that are related to motoric functions.
TOP: MRI images showing tumor on the left frontal lobe of the brain; MIDDLE: Corresponding Brain ECVT images of intracranial electrical activity after average value subtraction, showing electrical charge accumulation surrounding the location (red circles) of the tumor which is indicated by relatively low activity; BOTTOM: Brain ECVT image on the cortex showing low activity on the tumor location and cortical parts affected by the tumor with corresponding MRI image. The accumulation of the electrical charge within the brain may relate to electrical spikes that cause seizure.
Detecting Tumors and its Cause to Brain Dysfunctions

The images of MRI (left) & ECVT (right) for Ependymoma case, showing mass in left frontal lobe (MRI) and low brain activity in left frontal lobe and occipital lobe and cerebelum (ECVT).

The images of MRI (left) & ECVT (right) for Oligodendroglioma case: Showing mass in left temporal lobe (MRI) and low brain activity in left frontal and temporal lobes (ECVT).

The images of MRI (left) & ECVT (right) for Craniopharyngioma case: showing mass at the position of optic chiasm (MRI) and low activity of both left and right frontal lobes and occipital lobe (ECVT).

The image of MRI (left) & ECVT (right) for Cerebellopontine angle tumor case: Showing in cerebelum (MRI) and low brain activity in occipital lobe and cerebelum (ECVT).

Brain dysfunction detected with Brain ECVT as compared with corresponding MRI and PET images.
## HARDWARE SYSTEM (Data Acquisition System and Sensor)

<table>
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<tr>
<th>Specification</th>
<th>Description</th>
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<tbody>
<tr>
<td>Data capture speed</td>
<td>ECVT system for brain and breast scan can produce three-dimensional images of electrical activity of the brain and the breast in real time</td>
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<tr>
<td>Sensitivity</td>
<td>The system is able to detect low electrical activities caused by abnormal physiological changes such as stressful mind for brain scan, and hormonal activity for breast scan to high electrical activities caused by tumors in the brain or the breast</td>
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<tr>
<td>Sensor Scanner</td>
<td>Helmet type sensor for brain scan, and cup type sensor for breast. The sensor system is connected to the data acquisition system through coaxial cables R5174</td>
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<tr>
<td>Computer System</td>
<td>The computer using the latest Multitasking with 64bit processor and a menu driven platform. With capacity hardisk storage 500GB or more for both image and raw data. The monitor using the latest colours of atleast 19 inches full flat screen LED with the display matrix 1024 x 1024 or more.</td>
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<tr>
<td>System connection</td>
<td>USB 2.0 to RS-232 serial link as well as HDMI connection</td>
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## SOFTWARE

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<tr>
<td>Image Reconstruction</td>
<td>ECVT Image Reconstruction Software based on ILBP algorithm running on Phyton 2.7</td>
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<td>Post-Processing Features</td>
<td>Real time 3D volume image/movie (4D image); various choices of 3D volume visualization based on Phyton 3D Graphic function; reconstructed image evaluation using root mean square error analysis, and 4D signal analysis using power spectrum, chaos analysis and wavelets.</td>
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