REAL- TIME FIELD DISTRIBUTION OF THE CLOSED OBJECT USING IMAGE RECONSTRUCTION TECHNIQUE

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ABSTRACT: Understanding of the anatomy and functions of an organ or a physiological process, various non-invasive imagining methods allow the clinicians to visualize and diagnose. The imagery is the richest source of information and the most important tool for well-being of the humans. The medical imaging techniques should be non-invasive to see inside the body. The image reconstruction methods have the power to see inside which the imaging device or naked eyes cannot see. The aim of this paper is to develop an image reconstruction algorithm which automatically form the nodes and find the unknown intensity of the closed objects or phantoms.

KEYWORDS: Imaging, IPG, image reconstruction, mesh.

INTRODUCTION

The medical imaging tool is a mean to look inside the body which is not seen by the naked eyes. There are various medical imaging modalities, a non-invasive and minimally invasive technique which are used to see the inner body anatomy and morphology for different inputs energy and generates different signals. These signal are monitored and captured at the surface of the human body and are considered to be signal output which represents the boundary conditions for image to be reconstructed. The signal arising from the patient depends on the physical process governing a given imaging modality. The final output is to create an image from the given boundary conditions through a mathematical image reconstruction algorithm. Voltage signal developed along the current path is sensed with the help of another pair of electrodes called the sensing electrodes or voltage electrodes V1 and V2. If sufficient data of surface voltages are logged for input energy, current patterns, the image can be reconstructed with the help of image reconstruction algorithm such as Finite Element Method (FEM) or Finite Difference Method (FDM) to create an image. Here an effort has been made to develop the image reconstruction algorithm which will generate the inner nodes for the given boundary condition. The inner nodes intensity is calculated and represents the conductance of the image to be reconstructed.

IMAGE RECONSTRUCTION ALGORITHM

In the IPG of 4 electrodes method, the constant magnitude ac current with frequency in KHz is inserted into subject/ phantom, supplied through two electrodes and the voltages produced inside is measured non-invasively between remaining two electrodes on the surface. The same procedure is applicable for imaging also where normally more that 8 electrodes are used. The governing equation of interest becomes the Laplace equation of voltage for non-homogeneous domain with irregular boundary shape and the calculus problem ($\nabla \rho$ - * $\nabla V = 0$) in converted into the algebraic problem (YV=C). The domain/closed object of interest where imaged to be reconstructed, is split into grid or mesh using image reconstruction algorithms. The pivotal values at the points of intersection, known as nodes, are denoted by f_{ij} which is a function of the two space variable x and y. The differential equations corresponding to each grid point using function values at the surrounding grid points are written by their finite difference equivalent. Solving these equations simultaneously gives values for the function at each grid point. The image reconstruction algorithm uses finite difference equivalents of the partial derivatives to construct various types of differential equations using Laplace equation. To solve the Laplace's Equation on a region in the xy-plane for 16 electrodes, subdivide the region as shown in figure 1, consider the portion of the region near (x_i , y_i). The approximate equation is written as: $\begin{aligned} \nabla^2 f &= \partial^2 f / \partial x^2 + \partial^2 f / \partial y^2 = 0 \end{aligned} (1) \\ \text{Replacing the second-order derivatives by their finite difference equivalents at the point (xi, yi), and is written as} \\ \nabla^2 f i j &= 1/h2 \left[(fi+1, j+fi-1, j-4fij+fi, j+1+fi, j-1) \right] = 0 \end{aligned} (2) \\ \text{Or} \\ f i j &= 1/4 \left(fi+1, j+fi-1, j+fi, j+1+fi, j-1 \right) \end{aligned} (3)$

Eq. 3 contains four neighboring points around the central point (xi, yj) as shown in figure 1 also.

METHODOLOGY

For N-electrode system, apply a set of N/2 current patterns oppositively. The corresponding voltages patterns are measured and denote by V_1 , V_2 ... $V_{N^*(N-3)/2}$. For finding the field distribution inside the object/ closed object, the software is developed which will generates the mesh automatically. The software is user friendly and graphically interactive. For discretisation, the closed object/domain is divided into a finite number of nodes with boundary conditions; a mesh is generated, with nodes of unknown intensity. After generation of grid the boundary condition are entered and embedded outside the grid. The software itself generates the equations of g_{ij} for all nodes which are stored in the form of [G][V] = [I] which are solved for finding conductivity distribution inside the object.



Figure 1. Two-dimensional finite difference grid

Following are the actions performed by the software application design for constructing a mesh:

- 1. Loading of input file containing voltage values.
- 2. Defining rows and columns of the grid
- 3. Validating the input and generating the grid with the supplied values. (Template of the final grid to be generated)
- 4. Form containing the result calculated with the defined formula. (as shown in figure 2)



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upila		V96	V95	V94	V93	V92	V91	V90	V89	V88	V87	V86	V85	V84	V83	V82	V81	V80	V79	V78	V77	V76	V75	V74	V73	
8	V1	a1	a2	a3	a4	a5	a6	a7	a8	a9	a10	a11	a12	a13	a14	a15	a16	a17	a18	a19	a20	a21	a22	a23	a24	V72
1910	V2	g25	g26	g27	g28	g29	g30	g31	g32	g33	g34	g35	g36	g37	g38	g39	g40	g41	g42	g43	g44	g45	g46	g47	g48	V71
	V 3	g49	g50	g51	g52	g53	g54	g55	g56	g57	g58	g59	g60	g61	g62	g63	g64	g65	g66	g67	g68	g69	g70	g71	g72	V70
1	V4	g73	g74	g75	g76	g77	g78	g79	g80	g81	g82	g83	g84	g85	g86	g87	g88	g89	g90	g91	g92	g93	g94	g95	g96	V69
1650	V 5	g97	g98	g99	g100	g101	g102	g103	g104	g105	g106	g107	g108	g109	g110	g111	g112	g113	g114	g115	g116	g117	g118	g119	g120	V68
_	V 6	g121	g122	g123	g124	g125	g126	g127	g128	g129	g130	g131	g132	g133	g134	g135	g136	g137	g138	g139	g140	g141	g142	g143	g144	V67
	V7	g145	g146	g147	g148	g149	g150	g151	g152	g153	g154	g155	g156	g157	g158	g159	g160	g161	g162	g163	g164	g165	g166	g167	g168	V66
	V8	g169	g170	g171	g172	g173	g174	g175	g176	g177	g178	g179	g180	g181	g182	g183	g184	g185	g186	g187	g188	g189	g190	g191	g192	V65
	V 9	g193	g194	g195	g196	g197	g198	g199	g200	g201	g202	g203	g204	g205	g206	g207	g208	g209	g210	g211	g212	g213	g214	g215	g216	V64
	V10	g217	g218	g219	g220	g221	g222	g223	g224	g225	g226	g227	g228	g229	g230	g231	g232	g233	g234	g235	g236	g237	g238	g239	g240	V63
	V11	g241	g242	g243	g244	g245	g246	g247	g248	g249	g250	g251	g252	g253	g254	g255	g256	g257	g258	g259	g260	g261	g262	g263	g264	V62
	V12	g265	g266	g267	g268	g269	g270	g271	g272	g273	g274	g275	g276	g277	g278	g279	g280	g281	g282	g283	g284	g285	g286	g287	g288	V61
	V13	g289	g290	g291	g292	g293	g294	g295	g296	g297	g298	g299	g300	g301	g302	g303	g304	g305	g306	g307	g308	g309	g310	g311	g312	V60
	V14	g313	g314	g315	g316	g317	g318	g319	g320	g321	g322	g323	g324	g325	g326	g327	g328	g329	g330	g331	g332	g333	g334	g335	g336	V59
	V15	g337	g338	g339	g340	g341	g342	g343	g344	g345	g346	g347	g348	g349	g350	g351	g352	g353	g354	g355	g356	g357	g358	g359	g360	V58
	V16	g361	g362	g363	g364	g365	g366	g367	g368	g369	g370	g371	g372	g373	g374	g375	g376	g377	g378	g379	g380	g381	g382	g383	g384	V57
	V17	g385	g386	g387	g388	g389	g390	g391	g392	g393	g394	g395	g396	g397	g398	g399	g400	g401	g402	g403	g404	g405	g406	g407	g408	V56
	V18	g409	g410	g411	g412	g413	g414	g415	g416	g417	g418	g419	g420	g421	g422	g423	g424	g425	g426	g427	g428	g429	g430	g431	g432	V55
	V19	g433	g434	g435	g436	g43/	g438	g439	g440	g441	g442	g443	g444	g445	g446	g44/	g448	g449	g450	g451	g452	g453	g454	g455	g456	V54
	V20	g45/	g458	g459	g460	g461	g462	g463	g464	g465	g466	g46/	g468	g469	g4/0	g4/1	g4/2	g4/3	g4/4	g4/5	g4/6	g4//	g4/8	g4/9	g480	V53
	V21	g481	g482	g483	g484	g485	g486	g487	g488	g489	g490	g491	g492	g493	g494	g495	g496	g497	g498	g499	g500	g501	g502	g503	g504	V52
	V22	g505	g506	g507	g508	g509	g510	g511	g512	g513	g514	g515	g516	g51/	g518	g519	g520	g521	g522	g523	g524	g525	g526	g527	g528	V51
	V23	g529	g530	g531	g532	g533	g534	g535	g536	g537	g538	g539	g540	g541	g542	g543	g544	g545	g546	g547	g548	g549	g550	g551	g552	V50
	V24	g553	g554	g555	g556	g55/	g558	g559	g560	g561	g562	g563	g564	g565	g566	g567	g568	g569	g570	g5/1	g5/2	g5/3	g5/4	g5/5	g576	V49
		V25	V26	V27	V28	V29	V30	V31	V32	V33	V34	V35	V36	V37	V38	V39	V40	V41	V42	V43	V44	V45	V46	V47	V48	
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Figure 2. Template grid with supplied voltages and Vi (boundary conditions) is the voltages from the input file. And gij are the unknown values that are to be calculated with the image reconstruction algorithm

IMPLEMENTATION AND RESULT

The proposed algorithm can be implemented for any number electrodes configuration for mesh and boundary conditions. Here the 8 current patterns are applied and measurements of voltages are made on the other electrodes. The total number of boundary measured voltages is 104. The grid takes 26, rows and columns to create a grid. The mesh will have 678 nodes or pixels and same number of equations. The software automatically generates the equations and solves them all for finding the G_{ij} which is the pixel intensity of the conductive image in the closed region. The front panel of which is shown in figure 3. Software is implemented to generate the mesh and unknown pixel intensity is calculated by the algorithms for image formation. The snap shot of which is shown in figure 4.



Figure 3. Front panel of the mesh formation

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figura			0.00	22	07	0.02	0.02	0.05	0.00	0.00	0.00	2 40	0.7	0.02	0.02	0.05	0.00	0.00	0.7	2 47	0.7	0.62	0.62	0.05	0.07	0.00	
Col		0.00	0.69	3.2	0.1	0.62	0.63	0.05	0.66	0.00	0.09	3.40	0.1	0.62	0.63	0.65	0.00	0.60	0.7	3.17	0.7	0.02	0.63	0.65	0.67	0.00	0.7
ate		0.69	0.26	0.15	0.15	0.15	0.15	0.15	0.15	0.25	0.27	0.15	0.15	0.15	0.15	0.15	0.15	0.27	0.25	0.15	0.15	0.15	0.15	0.15	0.15	0.25	3.5
emp		0.66	0.13	0.03	0.03	0.03	0.03	0.03	0.03	0.13	0.15	0.03	0.03	0.02	0.03	0.02	0.03	0.15	0.13	0.03	0.03	0.02	0.03	0.03	0.03	0.13	0.7
		0.64	0.13	0.03	0.03	0.03	0.03	0.03	0.03	0.13	0.15	0.03	0.03	0.03	0.03	0.03	0.03	0.15	0.13	0.03	0.03	0.03	0.03	0.03	0.03	0.13	0.62
Sesu		0.63	0.13	0.03	0.03	0.03	0.03	0.03	0.03	0.13	0.15	0.03	0.03	0.02	0.03	0.02	0.03	0.15	0.13	0.03	0.03	0.02	0.03	0.03	0.03	0.13	0.64
nt 1		0.71	0.13	0.03	0.03	0.03	0.03	0.03	0.03	0.13	0.15	0.03	0.03	0.03	0.03	0.03	0.03	0.15	0.13	0.03	0.03	0.03	0.03	0.03	0.03	0.13	0.65
Outp		0.69	0.14	0.03	0.03	0.03	0.03	0.03	0.03	0.13	0.15	0.03	0.03	0.03	0.03	0.03	0.03	0.15	0.14	0.03	0.03	0.03	0.03	0.03	0.03	0.13	0.67
Inal		0.71	0.14	0.03	0.03	0.03	0.03	0.03	0.03	0.13	0.15	0.03	0.03	0.03	0.03	0.03	0.03	0.15	0.14	0.03	0.03	0.03	0.03	0.03	0.03	0.13	0.68
<u> </u>		0.69	0.24	0.14	0.13	0.13	0.13	0.13	0.14	0.23	0.25	0.14	0.13	0.13	0.13	0.13	0.14	0.25	0.24	0.14	0.13	0.13	0.13	0.13	0.14	0.24	0.7
		0.67	0.14	0.03	0.03	0.03	0.03	0.03	0.03	0.13	0.15	0.03	0.03	0.03	0.03	0.03	0.03	0.15	0.14	0.03	0.03	0.03	0.03	0.03	0.03	0.13	3.13
		0.60	0.13	0.03	0.03	0.03	0.03	0.03	0.03	0.13	0.15	0.03	0.03	0.02	0.03	0.02	0.03	0.15	0.13	0.03	0.03	0.02	0.03	0.03	0.03	0.13	0.62
		0.63	0.13	0.03	0.03	0.03	0.03	0.03	0.03	0.13	0.15	0.03	0.03	0.02	0.03	0.02	0.03	0.15	0.13	0.03	0.03	0.02	0.03	0.03	0.03	0.13	0.64
		0.71	0.13	0.03	0.03	0.03	0.03	0.03	0.03	0.13	0.15	0.03	0.03	0.03	0.03	0.03	0.03	0.15	0.13	0.03	0.03	0.03	0.03	0.03	0.03	0.13	0.65
		3.06	0.14	0.03	0.03	0.03	0.03	0.03	0.03	0.13	0.15	0.03	0.03	0.03	0.03	0.03	0.03	0.15	0.14	0.03	0.03	0.03	0.03	0.03	0.03	0.13	0.67
		0.7	0.24	0.13	0.13	0.13	0.13	0.13	0.13	0.23	0.25	0.13	0.13	0.13	0.13	0.13	0.13	0.25	0.24	0.13	0.13	0.13	0.13	0.13	0.13	0.23	0.68
		0.69	0.26	0.15	0.15	0.15	0.15	0.15	0.15	0.25	0.27	0.15	0.15	0.15	0.15	0.15	0.15	0.27	0.25	0.15	0.15	0.15	0.15	0.15	0.15	0.25	0.7
		0.67	0.14	0.03	0.03	0.03	0.03	0.03	0.03	0.13	0.15	0.03	0.03	0.03	0.03	0.03	0.03	0.15	0.14	0.03	0.03	0.03	0.03	0.03	0.03	0.13	3.51
		0.66	0.13	0.03	0.03	0.03	0.03	0.03	0.03	0.13	0.15	0.03	0.03	0.02	0.03	0.02	0.03	0.15	0.13	0.03	0.03	0.02	0.03	0.03	0.03	0.13	0.7
		0.64	0.13	0.03	0.03	0.03	0.03	0.03	0.03	0.13	0.15	0.03	0.03	0.03	0.03	0.03	0.03	0.15	0.13	0.03	0.03	0.03	0.03	0.03	0.03	0.13	0.62
		0.63	0.13	0.03	0.03	0.03	0.03	0.03	0.03	0.13	0.15	0.03	0.03	0.02	0.03	0.02	0.03	0:15	0.13	0.03	0.03	0.02	0.03	0.03	0.03	0.13	0.64
		3.51	0.13	0.03	0.03	0.03	0.03	0.03	0.03	0.13	0.15	0.03	0.03	0.03	0.03	0.03	0.03	0.15	0.13	0.03	0.03	0.03	0.03	0.03	0.03	0.13	0.67
		0.7	0.26	0.15	0.15	0.15	0.15	0.15	0.15	0.25	0.27	0.15	0.15	0.15	0.15	0.15	0.05	0.27	0.25	0.15	0.15	0.15	0.15	0.15	0.15	0.25	0.68
			0.69	0.67	0.66	0.64	0.63	0.71	3.08	0.7	0.69	0.67	0.65	0.64	0.62	0.7	3.51	0.7	0.68	0.67	0.65	0.64	0.62	0.7	3.11	0.7	
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Figure 4. The mesh shows the boundary voltages and unknown pixel intensity generated by the software

The proposed algorithm when applied for N=10 number of electrodes, the output of grid of 100 nodes are generated, marked as G_{ij} (G_1 - G_{100}). The equations are generated for these nodes and the unknown values of G_{ij} are calculated and put back into the nodes which correspond to the intensity or conductivity values at those nodes. The complete procedure is shown in figure 5.



Figure 5(a). Grid of 100 nodes

0.3 + g2 + 0.42 + g11 -4xg1 = 0 ,g1 + g3 + 0.19 + g12 -4xg2 = 0,g2 + g4 + 0.33 + g13 -4xg3 = 0,g3 + g5 + 0.69 + g14 -4xg4 = 0,g4 + g6 + 0.4 + g15 - 0.59 + g14 - 0.59 + 0.59 4xg5 = 0,g5 + g7 + 0.98 + g16 - 4xg6 = 0,g6 + g8 + 0.54 + g17 - 4xg7 = 0,g7 + g9 + 0.59 + g18 - 4xg8 = 0,g8 + g10 + 0.41 + g19 - 4xg9 = 0,g9 + 0.23 + 0.35 + g20 - 4xg10 = 0, 0.26 + g12 + g1 + g21 - 4xg11 = 0, g11 + g13 + g2 + g22 - 4xg12 = 0, g12 + g14 + g3 + g23 - 4xg13 = 0, g13 + g15 + g4 + g24 - g12 + g14 + g144xg14 = 0,g14 + g16 + g5 + g25 - 4xg15 = 0,g15 + g17 + g6 + g26 - 4xg16 = 0,g16 + g18 + g7 + g27 - 4xg17 = 0,g17 + g19 + g8 + g28 - 4xg18 = 0,g18 + g18 +g20 + g9 + g29 -4xg19 = 0,g19 + 0.24 + g10 + g30 -4xg20 = 0,0.23 + g22 + g11 + g31 -4xg21 = 0,g21 + g23 + g12 + g32 -4xg22 = 0,g22 + g24 + g13 + g33 -4xg23 = 0,g23 + g25 + g14 + g34 -4xg24 = 0,g24 + g26 + g15 + g35 -4xg25 = 0,g25 + g27 + g16 + g36 -4xg26 = 0,g26 + g28 + g17 + g37 -4xg27 = 0,g27 + g29 + g18 + g38 - 4xg28 = 0,g28 + g30 + g19 + g39 - 4xg29 = 0,g29 + 0.25 + g20 + g40 - 4xg30 = 0,0.18 + g32 + g21 + g41 - 4xg31 = 0,0.18 + g32 + g21 + g41 - 4xg31 = 0,0.18 + g32 + g21 + g41 - 4xg31 = 0,0.18 + g32 + g31 + g31 0,g31 + g33 + g22 + g42 -4xg32 = 0,g32 + g34 + g23 + g43 -4xg33 = 0,g33 + g35 + g24 + g44 -4xg34 = 0,g34 + g36 + g25 + g45 -4xg35 = 0,g35 + g37 + g26 + g46 -4xg36 = 0,g36 + g38 + g27 + g47 -4xg37 = 0,g37 + g39 + g28 + g48 -4xg38 = 0,g38 + g40 + g29 + g49 -4xg39 = 0,g39 + 0.25 + g30 + g50 -4xg40 = 0,0.14 + g42 + g31 + g51 -4xg41 = 0,g41 + g43 + g32 + g52 -4xg42 = 0,g42 + g44 + g33 + g53 -4xg43 = 0,g43 + g45 + g34 + g54 -4xg44 = 0,g44 + g46 + g35 + g55 -4xg45 = 0,g45 + g47 + g36 + g56 -4xg46 = 0,g46 + g48 + g37 + g57 -4xg47 = 0,g47 + g49 + g38 + g58 -4xg48 = 0,g46 + g48 + g37 + g57 -4xg47 = 0,g47 + g49 + g38 + g58 -4xg48 = 0,g46 + g48 + g37 + g57 -4xg47 = 0,g47 + g49 + g38 + g58 -4xg48 = 0,g46 + g48 + g37 + g57 -4xg47 = 0,g47 + g49 + g38 + g58 -4xg48 = 0,g46 + g48 + g37 + g57 -4xg47 = 0,g47 + g49 + g38 + g58 -4xg48 = 0,g46 + g48 + g37 + g57 -4xg47 = 0,g47 + g49 + g38 + g58 -4xg48 = 0,g46 + g48 + g37 + g57 -4xg47 = 0,g47 + g49 + g38 + g58 -4xg48 = 0,g46 + g48 + g56 -4xg46 = 0,g46 + g48 + g57 -4xg47 = 0,g47 + g49 + g38 + g58 -4xg48 = 0,g46 + g48 + g57 -4xg47 = 0,g47 + g49 + g38 + g58 -4xg48 = 0,g46 + g48 + g56 -4xg46 = 0,g46 + g48 + g56 -4xg47 = 0,g47 + g58 + g58 -4xg48 = 0,g46 + g58 + g5 0,g48 + g50 + g39 + g59 - 4xg49 = 0,g49 + 0.19 + g40 + g60 - 4xg50 = 0,0.18 + g52 + g41 + g61 - 4xg51 = 0,g51 + g53 + g42 + g62 - 4xg52 = 0,g52 + g53 + g5g54 + g43 + g63 -4xg53 = 0,g53 + g55 + g44 + g64 -4xg54 = 0,g54 + g56 + g45 + g65 -4xg55 = 0,g55 + g57 + g46 + g66 -4xg56 = 0,g56 + g58 + g47 + g67 -4xg57 = 0,g57 + g59 + g48 + g68 -4xg58 = 0,g58 + g60 + g49 + g69 -4xg59 = 0,g59 + 0.31 + g50 + g70 -4xg60 = 0,0.28 + g62 + g51 + g71 -4xg61 = 0,g61 + g63 + g52 + g72 -4xg62 = 0,g62 + g64 + g53 + g73 -4xg63 = 0,g63 + g65 + g54 + g74 -4xg64 = 0,g64 + g66 + g55 + g75 -4xg65 = 0,g64 + g56 + g5 0,g65 + g67 + g56 + g76 -4xg66 = 0,g66 + g68 + g57 + g77 -4xg67 = 0,g67 + g69 + g58 + g78 -4xg68 = 0,g68 + g70 + g59 + g79 -4xg69 = 0,g69 + 0.22 + g60 + g80 -4xg70 = 0,0.16 + g72 + g61 + g81 -4xg71 = 0,g71 + g73 + g62 + g82 -4xg72 = 0,g72 + g74 + g63 + g83 -4xg73 = 0,g73 + g75 + g64 + g84 -4xg74 = 0,g74 + g76 + g65 + g85 -4xg75 = 0,g75 + g77 + g66 + g86 -4xg76 = 0,g76 + g78 + g67 + g87 -4xg77 = 0,g77 + g79 + g68 + g88 -4xg78 = 0,g78 + g80 + g69 + g89 -4xg79 = 0,g79 + 0.4 + g70 + g90 -4xg80 = 0,0.15 + g82 + g71 + g91 -4xg81 = 0,g81 + g83 + g72 + g92 -4xg82 = 0,g82 + g84 + g73 + g93 -4xg83 = 0,g83 + g85 + g74 + g94 -4xg84 = 0,g84 + g86 + g75 + g95 -4xg85 = 0,g85 + g87 + g76 + g96 -4xg86 = 0,g86 + g88 + g77 + g97 -4xg87 = 0,g87 + g89 + g78 + g98 -4xg88 = 0,g88 + g90 + g79 + g99 -4xg89 = 0,g89 + 0.33 + g80 + g100 -4xg90 = 0,0.21 + g92 + g81 + 0.16 -4xg91 = 0,g91 + g93 + g82 + 0.15 -4xg92 = 0,g92 + g94 + g83 + 0.07 -4xg93 = 0,g93 + g95 + g84 + 0.27 -4xg94 = 0,g94 + g96 + g85 + 0.23 -4xg95 = 0,g95 + g97 + g86 + 0.28 -4xg96 = 0,g96 + g98 + g87 + 0.26 -4xg97 = 0,g97 + g99 + g88 + 0.31 -4xg98 = 0,g98 + g100 + g89 + 0.4 -4xg99 = $0.999 \pm 0.31 \pm 0.90 \pm 0.33 - 4 \times 0.00 = 0$

Figure 5(b). 100 Equations generated by the software

Figure 5 Results of the Algorithm. Figure 5a shows the grid of 100 nodes with 40 boundary voltages. In figure 5 b the equations are generated by software and are solved. In figure 5(c) the unknown values of Gij are calculated with the image reconstruction algorithm for image formation and inserted into the nodes which correspond to the intensity or conductivity values at those nodes.



Figure 5 (c). After solving the o is replaced by values

CONCLUSION

The proposed algorithm can be implemented for any number electrodes configuration in medical imaging techniques for image reconstruction. The N/2 current patterns are applied and measurements are made on the other electrodes. The total number of boundary measured voltages is N (N-3)/2. Therefore take [N (N-3)/2]/4 rows and columns to create a grid which correspond to [N (N-3)/2]/4 x[N (N-3)/2]/4 nodes or pixels and same number of equations. The software automatically generates the equations and solves them all for finding the unknown pixel intensity of the conductive image in the closed region.

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The software design here is user friendly and generates meshes, nodes and equations automatically for any length of nodes. The software also has a capability to solve these equations which represent the pixel intensity in term of conductivity distribution inside the closed object. The algorithm has very wide application in biomedical area especially in the field of electrical impedance tomography. Also same algorithm can be applied to non-medical such as in industrial processes.

The main objective here is to use the same software in reconstruction of an image of a phantom and human uterus and fetus.

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