Electrical resistance analysis of material using a colour bar scale in two-dimensional electrical impedance tomography (EIT)

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Abstract. Image reconstruction by adding colour bar scale has been implemented in the two-dimensional Electrical Impedance Tomography (EIT) to distinguish the electrical resistance of the material. The EIT technique is performed by injecting a low constant electric current of 1 mA at 20 kHz frequency on a pair of electrodes of 16 copper electrodes (Cu) surrounding a medium filled with saline solution, aluminium, PVC, and PE material. Voltage measurements from the other electrode pair were achieved by the principle of the neighbouring method. The measurement data is processed with the python program using gauss-newton algorithm to obtain a reconstructed image of materials. The results from the reconstructed image show that the higher the colour bar number, the lower the electrical resistance, while the lower the colour bar number, the higher the electrical resistance. The difference in electrical resistance of material can be obtained from analysis of colour bar scale in two-dimensional electrical impedance tomography.

1. Introduction
The technique of disease diagnosis is one of the technologies being developed in the health field recently. One of these is the technique of imaging or also called tomography. Tomography is a technique done by studying the network structure of living things in the form of images. There is a wide variety of tomography including CT Scan and MRI (Magnetic Resonance Imaging). Both of these techniques require a cost that is not cheap, so it is necessary to develop a technique that is considered cheaper and more efficient, one of which is Electrical Impedance Tomography (EIT) [1-5].

Electrical Impedance Tomography (EIT) is imaging techniques that can detect the existence of an object/material by measuring the electrical value of the material. Measurements are made using electrodes that have been prepared on the surface of the imaged material [2]. The basic principle of EIT is to see the difference in electrical characteristics of each material. Differences in the value of these characteristics can be used to distinguish or detect the presence of abnormalities in a medium [3-5]. This EIT is performed by injecting a low electrical current into an object that has been surrounded by surrounding electrodes. After the current is injected, the output measured by the electrode is a voltage used to find the value of the conductivity and resistivity distribution on the material object then displayed in the form of an image with the help of algorithm [4-5].

In the present study, the electrical resistance from the different material will be investigated using two-dimensional electrical impedance tomography with colour bar scale analysis.
2. Method
The EIT technique is performed by injecting a low constant electric current of 1 mA at a frequency of 20 kHz on a pair of electrodes of 16 copper electrodes (Cu) surrounding a medium filled with saline solution as a homogeneous state. Inhomogenous state where phantom contains a saline solution and object to be imaged which is in this research used aluminium, PVC (polyvinyl chloride), and PE (polyethylene). Voltage measurements from the other electrode pair were obtained using the principle of the neighbouring method. The measurement data is processed with the python program using gauss-newton algorithm to get a reconstructed image of the object.

3. Results and discussion
The reconstructed images display the conductivity and resistivity distribution of the material object related to electrical resistance. Value the conductivity of aluminium, PVC, and PE were 3.5x10⁻⁵ S/cm, 10⁻¹⁴–10⁻¹⁶ S/cm, and 10⁻¹⁶–10⁻₂⁰ S/cm, respectively [6].

The electrical resistance material can be identified from the colour bar scale of the reconstructed image. The colour of the aluminium image tends to be in the top position of the colour bar scale, while The colour of the PVC and PE image tend to be in the bottom position of the colour bar scale. Colour in the top position of the colour bar scale indicates the low electrical resistance. Instead, Colour in the bottom position of the colour bar scale indicates the high electrical resistance. PE has the highest electrical resistance than other two proven by image colour of object that tend to be in the lowest position than other two. It can be seen in table 1.

| Object position 1 | Reconstructed image | Object position 2 | Reconstructed image |
|-------------------|---------------------|-------------------|---------------------|
| ![Image 1]         | ![Image 2]          | ![Image 3]         | ![Image 4]          |
| ![Image 5]         | ![Image 6]          | ![Image 7]         | ![Image 8]          |
| ![Image 9]         | ![Image 10]         | ![Image 11]        | ![Image 12]         |
| ![Image 13]        | ![Image 14]         | ![Image 15]        | ![Image 16]         |

Table 1. The results of image reconstruction in two different position

| Object position 1 | Reconstructed image | Object position 2 | Reconstructed image |
|-------------------|---------------------|-------------------|---------------------|
| ![Image 1]         | ![Image 2]          | ![Image 3]         | ![Image 4]          |
| ![Image 5]         | ![Image 6]          | ![Image 7]         | ![Image 8]          |
| ![Image 9]         | ![Image 10]         | ![Image 11]        | ![Image 12]         |
| ![Image 13]        | ![Image 14]         | ![Image 15]        | ![Image 16]         |
The image object in the middle position requires a different colour bar range so that the object image can be appropriately detected because the sensitivity of the object when in the central position tends to be less than when in a location near the electrode [5]. It can be seen the results in table 2.

Table 2. The results of image reconstruction in the middle position

| Object | Reconstructed image |
|--------|---------------------|
| ![Image 1](image1.png) | ![Image 2](image2.png) |
| ![Image 3](image3.png) | ![Image 4](image4.png) |

Based on table 2 more clearly visible that aluminium has a small electrical resistance while PVC and PE material tend to have higher electrical resistance, especially PE which has the most significant electrical resistance compared to the other two. The lower the colour position of the colour bar scale, the higher the electrical resistance. Instead, the colour is at the top position of the colour bar scale then the electrical resistance is small.

4. Conclusion
Electrical resistance analysis of material using a colour bar scale has successfully studied. The higher the colour bar number, the lower the electrical resistance, while the lower the colour bar number, the higher the electrical resistance. The difference in electrical resistance of material can be obtained from analysis of colour bar scale in two-dimensional electrical impedance tomography.

5. References
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