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Editorial Board

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PREFACE

In the name of Allah, the Almighty who grants us knowledge, wisdom, and guidance, and with salutations upon the Prophet Muhammad (peace be upon him) who has shown us the way of truth and enlightenment, we begin this preface with gratitude. We are grateful to Allah for His blessings and strength that have enabled us to complete this proceedings.

This proceedings compiles the extended abstracts submitted to the **Johor International Innovation, Invention Competition and Symposium 2025 (JIIICaS 2025).** JIIICaS continues to serve as a virtual platform for students, researchers, and innovators to present their ideas and showcase their inventions. The programme aims to inspire creative thinking, encourage applied innovation, and nurture a spirit of collaboration among participants from diverse backgrounds.

Each abstract in this proceedings provides an overview of the respective innovation or project, highlighting the uniqueness, potential impact, and relevance to current technological and societal needs. It is our hope that this proceedings will become a source of reference and inspiration, not only for the participants but also for future innovators and change-makers. May the innovations presented here spark new ideas that lead to real-world solutions and meaningful progress.

We express our heartfelt appreciation to all contributors, supervisors, reviewers, and the entire organising committee whose dedication and commitment have brought JIIICaS 2025 to fruition.

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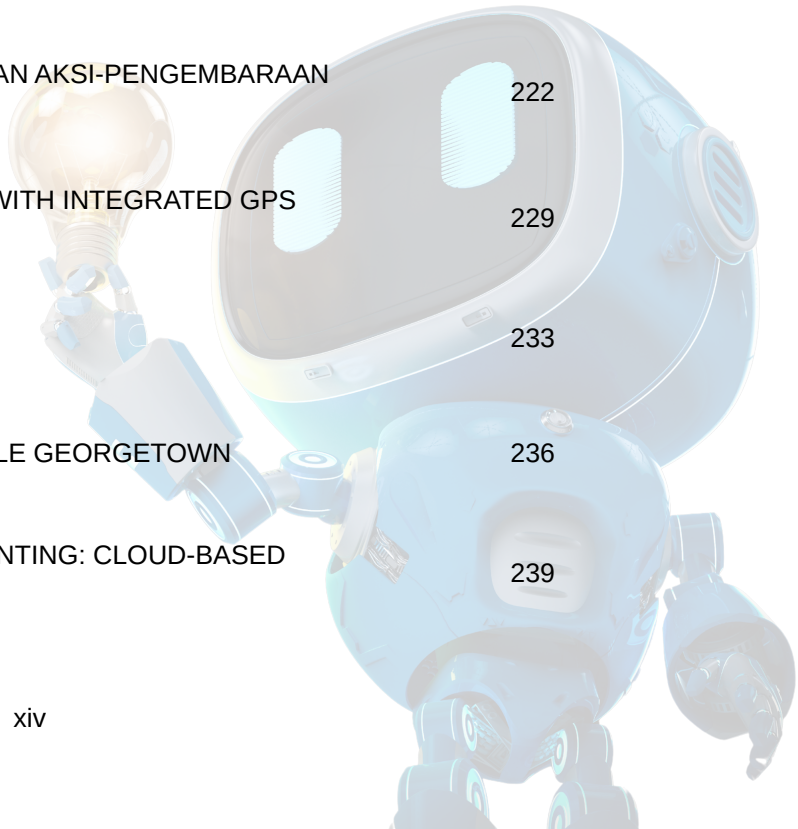

SPHEROIDAL FIRST ORDER POLARIZATION TENSOR (SFOPT)– FIXED VOLUME

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ABSTRACT

When a conducting object is presented in an electric or electromagnetic field, the perturbation on the field due to the presence of the object can be mathematically modelled as asymptotic series, where the dominant term of the series is called the Polarization Tensor (PT). In the applications of electric and electronic, PT has been adapted for many purposes such as to improve reconstruction of image in medical scanning and geophysics, or to enhance metal detection for security screening and landmine clearance. Besides, PT also appears in neuroscience after some researchers have used PT to study object recognition from electrical senses by electric fish. For each application, the PT might be able to describe some physical properties of the presented object such as the size, material or orientation of the object. Moreover, finding a spheroid that has the same first order PT as the original object represented by the PT is also useful especially to characterize the object if the object is not known. The spheroid and the object might have similar physical properties where; these properties can be revealed after the spheroid is obtained based on the given first order PT. In this study, given the first order PT of an unknown object, the conductivity and the depolarization factors for a spheroid will be determined by fixing the volume of the spheroid. Specifically, a Matlab GUI that can easily execute the computation will be presented. We focus on spheroids as previous studies have shown that the first order PT for many objects in the related applications are actually similar to the first order PT for the spheroids. Thus, understanding the first order PT for spheroids could be useful to describe those actual objects. Some examples will be included in this study to demonstrate the capability of the GUI.

Keywords: Spheroids, Electric Field, Conducting Object, Depolarization Factor, Matlab GUI

1.0 INTRODUCTION

Polarization tensor (PT) is a mathematical representation of how a conducting object affects the surrounding electric or electromagnetic field. The perturbation caused by the conducting object can be represented by an asymptotic formula, the simplest form is called the first order PT. In the related applications, PT can be used to improve electrical imaging or metal detection and also to study electric fish with a lower computational cost to characterize and describe objects in those applications (Ammari dan Kang (2007), Ahmad Khairuddin and Lionheart (2016), Ledger and Lionheart (2022)). This is because the PT does not require a full image or object reconstruction. Recently, finding a spheroid that has the same first order polarization tensor (PT) as the original object is also useful for characterizing the object, as the spheroid and the object may share similar physical properties. However, obtaining such a spheroid requires solving tedious mathematical equations, which can be error-prone and time consuming. Therefore, a platform that simplifies and facilitates the computation is greatly welcomed.

Therefore, this study proposes an innovation that can easily and accurately compute the conductivity and depolarization factors of a spheroid from a given first order PT, once its volume is specified. Once the parameters are obtained, the original object represented by the first order PT can then be described based on these parameters.

2.0 METHODOLOGY

In order to determine a spheroid from a given first order PT, the mathematical formulation of the GPT in Ammari dan Kang (2007) has been considered and simplified by assuming that the conducting object presented in an electric field is actually a spheroid. Previously, a method to determine a spheroid from a given first order PT when the conductivity is fixed has been discussed in Mohamad Yunos et al. (2019). In that study, the spheroid obtained will have the same conductivity with the original object represented

by the PT. In this study, a spheroid will be determined from a given first order PT after the volume is fixed, which means, now the spheroid and the original object represented by the first order PT will have the same volume. In this case, one might want to investigate how the conductivity differs between two objects that have the same first order PT and volume.

Now, consider a given first order PT for spheroid in the form

$$\begin{bmatrix} M_1 & 0 & 0 \\ 0 & M_2 & 0 \\ 0 & 0 & M_2 \end{bmatrix} \tag{2.1}$$

where, M_1 and M_2 are given. Our objective is to solve the conductivity k and also the depolarization factor d_1 when $|B|$ is fixed in the following nonlinear system of equations.

$$\begin{aligned} [|B| - M_1 d_1]k + M_1 d_1 &= M_1 + |B| \\ \left[|B| - \frac{M_2}{2} + \frac{M_2}{2} d_1\right] k - \frac{M_2}{2} d_1 &= |B| + \frac{M_2}{2}. \end{aligned} \tag{2.2}$$

The flowchart in the next page presents the algorithm to compute k and d_1 using the Newton's method.

3.0 THE INNOVATION SFOPT – FIXED VOLUME

Based on the given flowchart, a MATLAB GUI called as the Spheroidal First Order Polarization Tensor (SFOPT) – Fixed Volume, has been developed to compute $\boldsymbol{k}$ and $\boldsymbol{d_1}$ when $|\boldsymbol{B}|$ is fixed while $\boldsymbol{M_1}$ and $\boldsymbol{M_2}$ are given. Figure 2 shows the layout of the GUI. The GUI is an extension of our previous innovation, copyrighted under MyIPO with reference no CRLY2024J02487 where, our previous innovation determines the spheroid for fixed conductivity based on the method described in Ahmad Khairuddin et al. (2019). As required by the Newton's Method, initial values for both $\boldsymbol{k}$ and $\boldsymbol{d_1}$ must be specified by the user when using the GUI and this initial value can be specified based on the conditions stated in Ahmad Khairuddin et al. (2019). After using the GUI, user can straightaway describe the original object represented by the PT using the computed conductivity and the depolarization factor for spheroid.

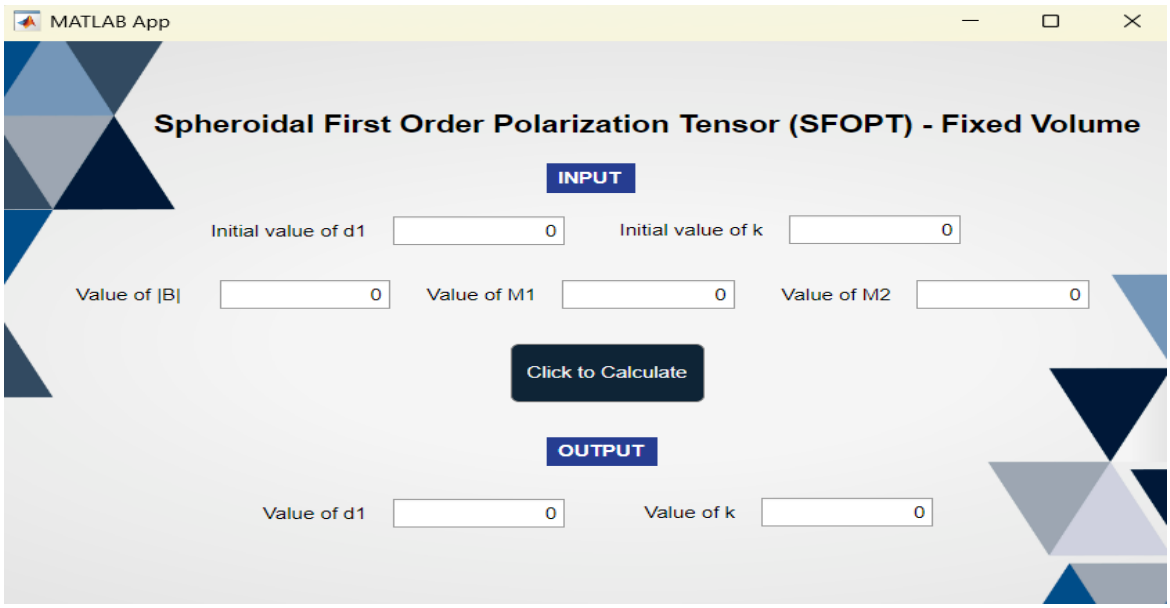

Figure 1: The layout for SFOPT – Fixed Volume

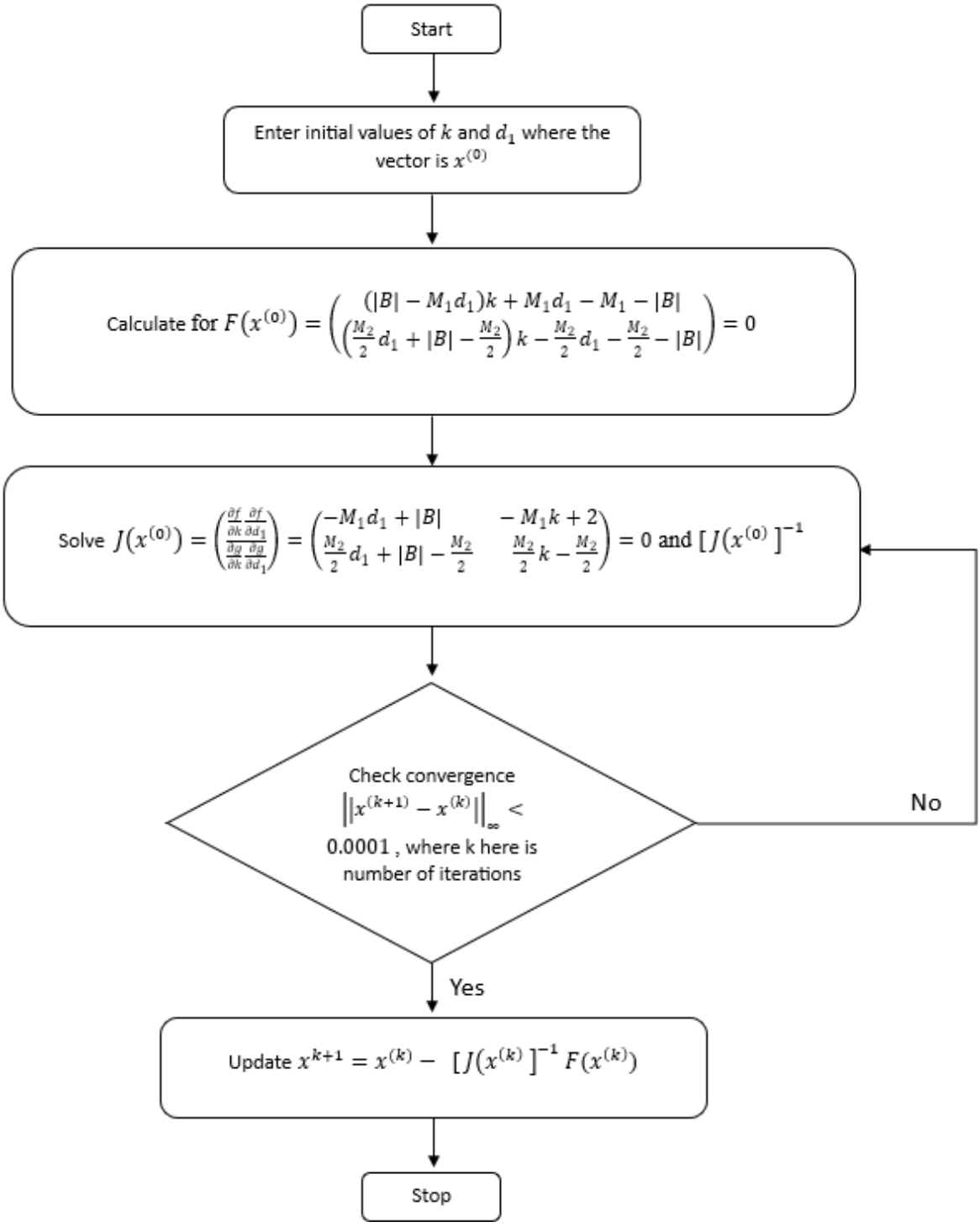

Figure 2: Flowchart of the Newton's method used in the innovation, which is a MATLAB GUI

4.0 EXAMPLES

Figure 3 and Figure 4 show two examples of using the GUI. The result in Figure 3 actually describes a pyramid at conductivity 500 from Ahmad Khairuddin and Lionheart (2013). On the other hand, Figure 4 describes hemisphere at conductivity 0.01, also from Ahmad Khairuddin and Lionheart (2013).

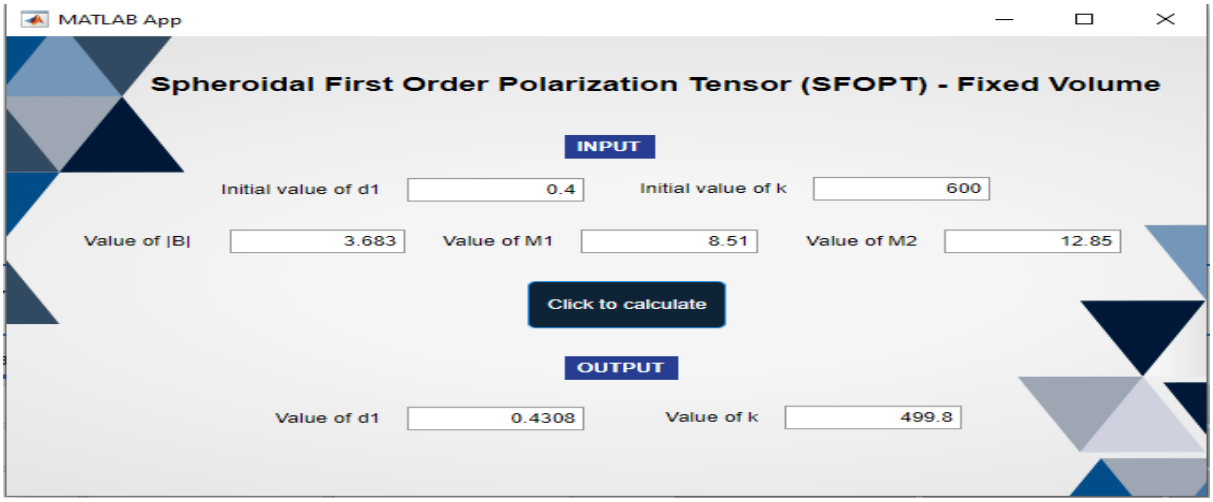

Figure 3: The value of k **and** d_1 when the given first order PT is for a pyramid at conductivity 500

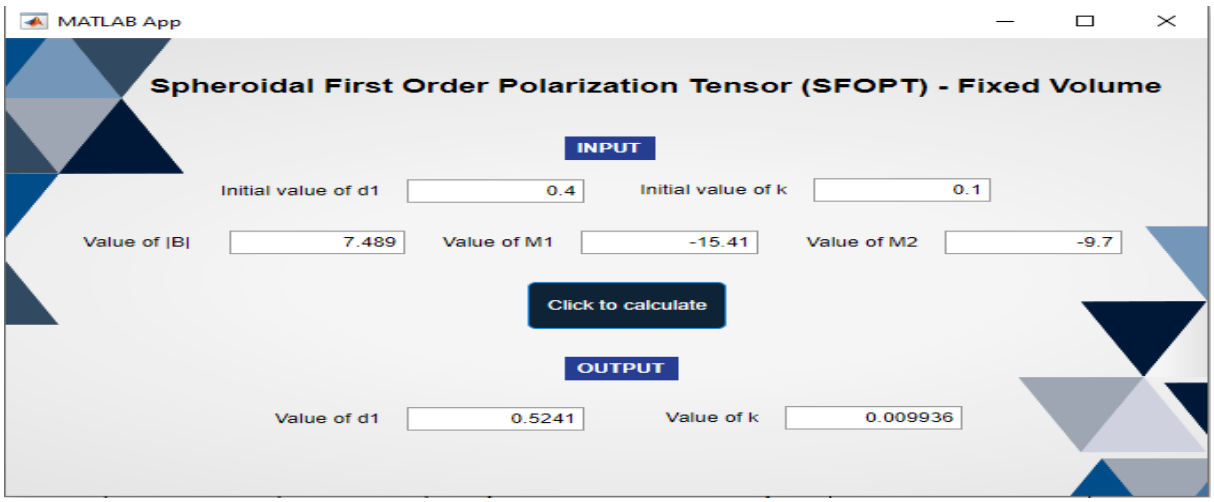

Figure 4: The value of k **and** d_1 when the given first order PT is for a hemisphere at conductivity 0.01

5.0 DISCUSSION AND CONCLUSION

The GUI provides an efficient way to determine a spheroid from a given first order PT for characterizing the related objects, which could be useful to engineers, physicists, and researchers engaged in problems involving object detection, shape estimation, or material characterization. As it helps describe objects, the GUI can be incorporated in the related industries, such as RAPISCAN System or Minelab Electronics to improve metal detection. It also encourages collaboration among STEM academicians and researchers including mathematicians, engineers, biologists and can be promoted in academia to stimulate broader knowledge development. Moreover, the GUI enhances students' grasp of theory and boosts hands-on practical skills, fostering deeper learning in higher education institutions. Thus, our innovation connects scientific concepts with creative and innovative thinking.

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