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Green Coordinates for Generation of Conformal Antenna Geometries

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I. INTRODUCTION

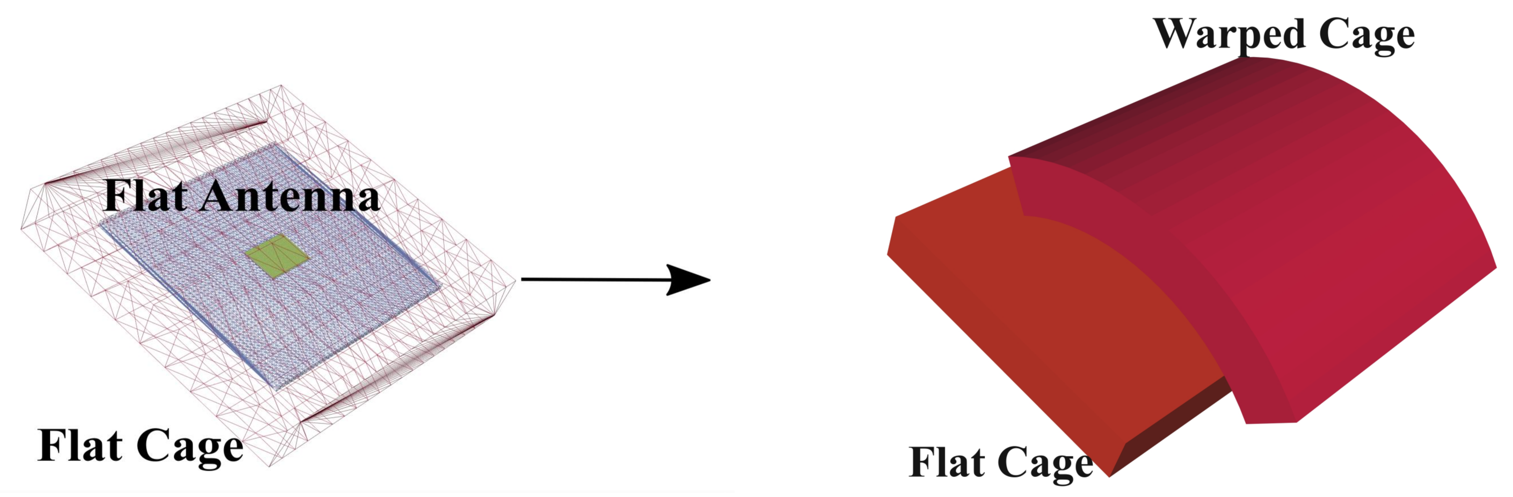
Conformal antennas have a great potential for a wide angle coverage for ground based communication application, biomedical sensor and RF energy harvesting device, low-mass cube-satellite or aerospace antenna without adding aerodynamic drag.

However, providing accurate geometrical models for antennas curved on single or double surface (as shown in Fig.1) is still a challenge. **In this work, we present a method for generating arbitrary antenna geometries, such as that shown in Fig.1, and an adaptive scaling process to compensate for errors induced by the 3D manipulation process.**

Fig.1. Double curved antenna array

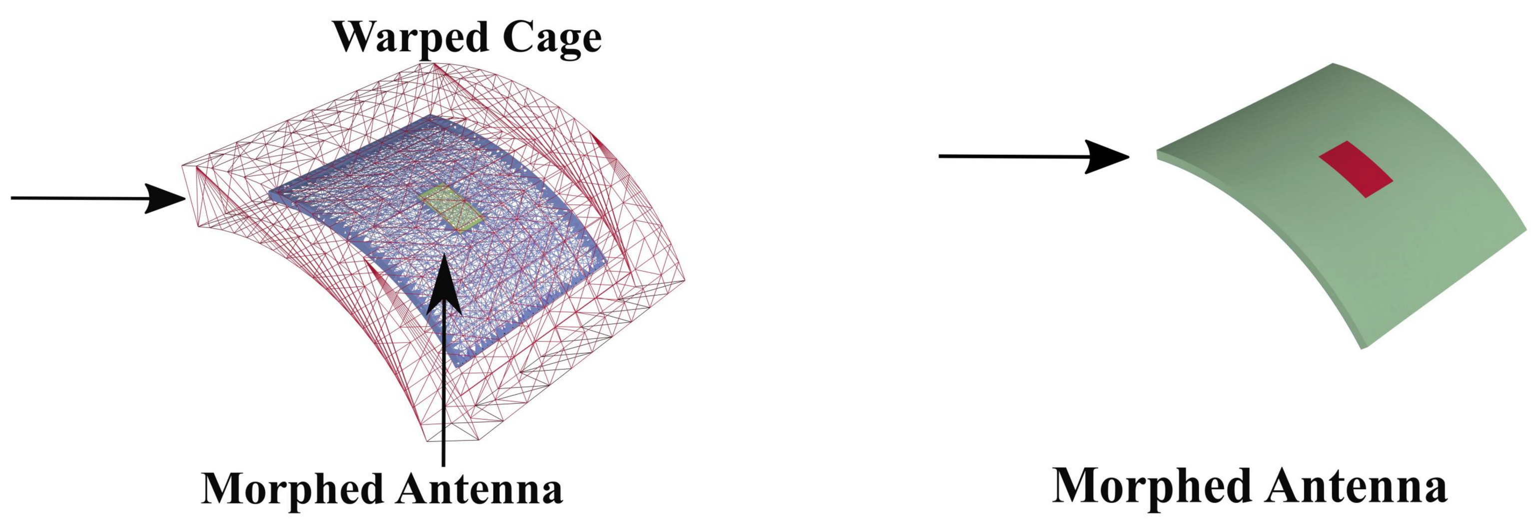
II. GENERATING ARBITRARY GEOMETRIES FOR ELECTROMAGNETICS SIMULATIONS

We adopt a method used in computer graphics - Green Coordinates (GC) to morph one object form to another by using special weight functions defined as coordinates [1,2]. The overall process of GC approach can be described in 4 stages:



Stage 1: Define a flat cage around the antenna. The cage is defined using a small number of vertices.

Stage 2: Manipulate the vertices of the flat cage and design a morphed cage that mimics the desired deformation.



Stage 3: Using the Green Coordinates formulae transfer the deformations of the cage onto the enclosed object i.e. antenna.

Stage 4: Remove the morphed cage retaining only the morphed antenna geometry.

Key feature: *Explicit* morphing of each of the *very many* vertices of the antenna is avoided, rather physical realistic deformations are achieved by morphing just a *few vertices* of the cage

However, GC method introduces unwanted distortion in 3D manipulation of objects.

These distortions are in this work reduced by:

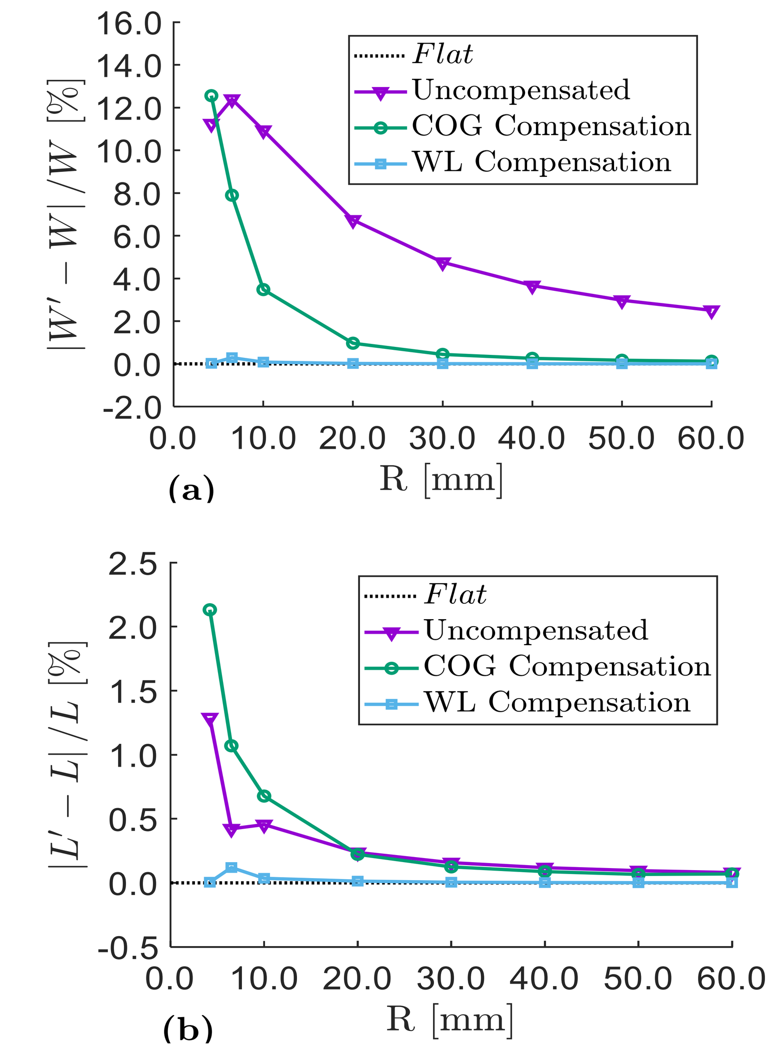
- Minimising the error in the centre of gravity position of triangular faces that make the object – **COG compensation**
- Compensating for the overall width and length of the antenna – **WL Compensation**

These compensation methods are compared with benchmark antennas bent over an ideal cylinder that can also be done accurately using Boolean geometry approach or Constructive Solid Geometry (CSG).

III. ELECTROMAGNETICS SIMULATIONS AND RESULTS

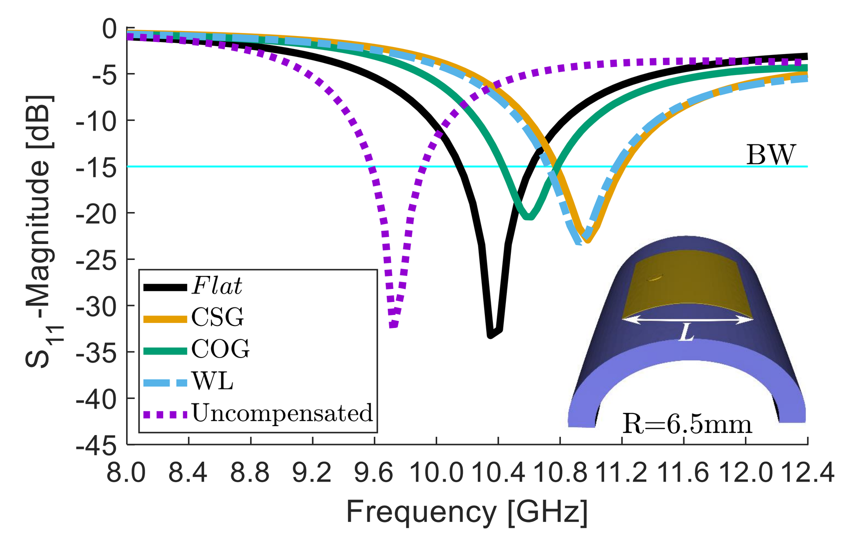
The simulations are performed using the Transmission Line Modelling method, based on unstructured tetrahedral mesh [3].

Compensated GC Geometry for cylindrical case:



Relative error of GC generated a) width and b) length of antenna to that of the flat antenna for uncompensated, COG and WL compensated antennas;

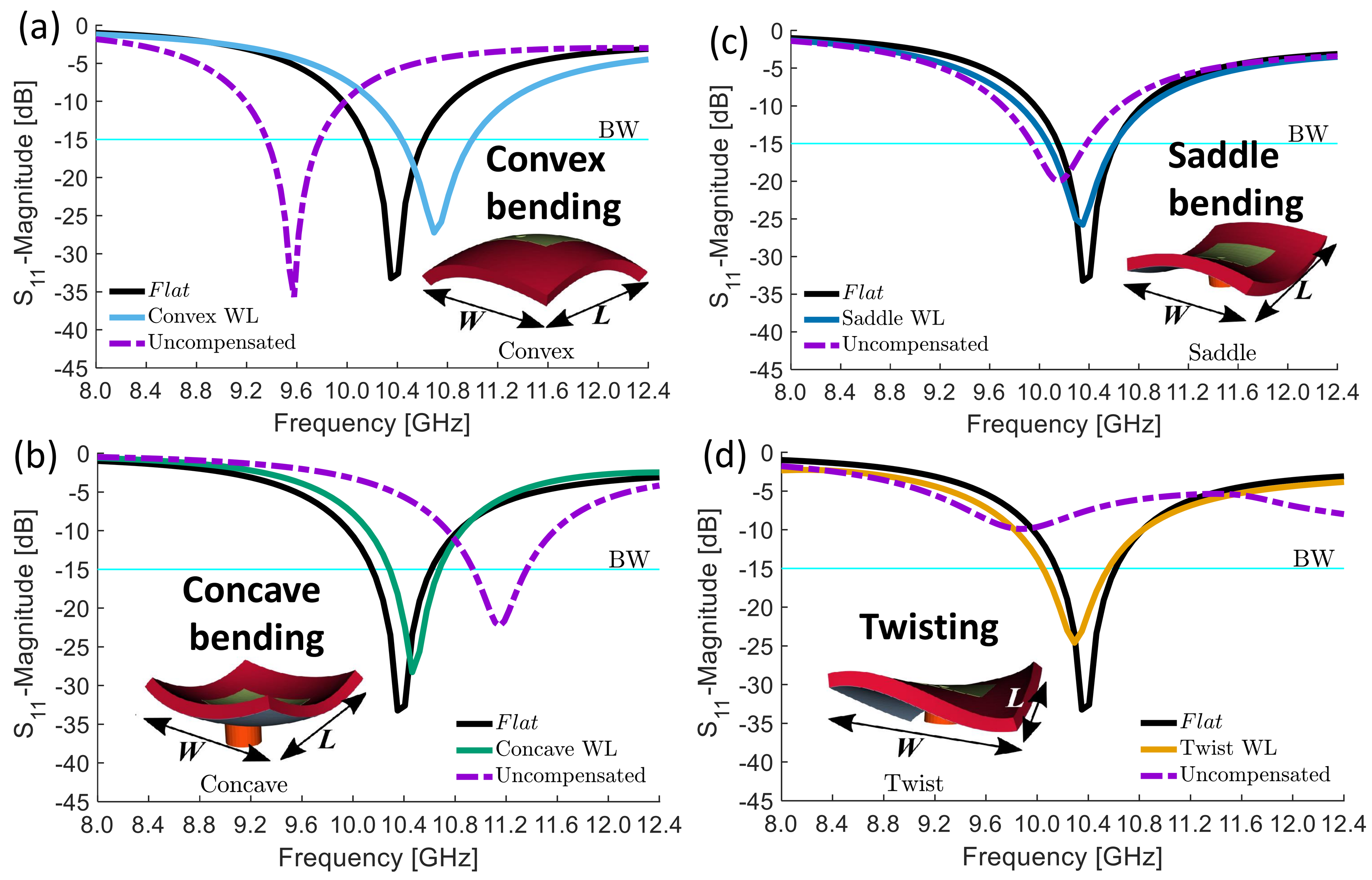
Width and Length compensation performs the best in terms of errors.



Comparison of S11 parameter for the flat antenna and antenna bent in the E-plane using uncompensated and compensated GC methods for radius R=6.5mm

Width and length compensation agrees the best with the CSG antenna model.

IV. PERFORMANCE OF ARBITRARILY DEFORMED ANTENNAS



Reflection coefficient of a) convex, b) concave, c) saddle, and d) twisted antenna obtained using original GC method and compensated GC method.

V. CONCLUSIONS

- GC method is a promising tool for generating arbitrary deformations of antenna;
- The results for such antenna geometries are the first to be obtained by any group in the world
- Adaptive pre-scaling of antenna is important for reducing GC induced deformations and accurate computation of S11 parameter;
- Distortions introduced by GC method do not significantly affect antenna far field.

[1] Y. Lipman and D. Levin, "Derivation and Analysis of Green Coordinates," *Computational Methods and Function Theory,* journal article vol. 10, no. 1, pp. 167-188, June 01 2010.
[2] Y. Lipman, D. Levin, and D. Cohen-Or, "Green Coordinates," *ACM Trans. Graph.,* vol. 27, no. 3, pp. 1-10, 2008.
[3] P. Sewell, T. M. Benson, C. Christopoulos, D. W. P. Thomas, A. Vukovic, and J. G. Wykes, "Transmission-line modeling (TLM) based upon unstructured tetrahedral meshes," *IEEE Transactions on Microwave Theory and Techniques,* vol. 53, no. 6, pp. 1919-1928, 2005.

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