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Improving the Gain of High-Gain Hilbert Space Filling Dental Antenna's for Biomedical Devices

ROHIT KUMAR BALYAN

M.Tech, E.C.E

Ajay Kumar Garg Engineering College,

Ghaziabad, India

Asst. Prof. RICHA

E.C.E. Department

Ajay Kumar Garg Engineering College,

Ghaziabad, India

ABSTRACT

In this paper a novel antenna for teeth implanting is propose, which may attach a low invasive biomedical device to monitor human beings dental and other cavity problems. A Hilbert-based curve 3D folded antenna is designed on ceramic denture (Z_rO_2) in Medical Implant Communication Service (MICS) band. Designed parameters are investigated to implant in different configurations. The dependence of the resonant frequency and input impedance of the printed dipole are determined for various dielectric properties and thicknesses.A proposed approach, Hilbert space filling antenna on the various parameters are studied and design curves are obtained. Current distribution along with different orders is compared with existing distribution along a printed dipole to examine the mechanism of the miniaturization. The miniaturization capability of the space filling Hilbert antenna is quantified by comparing the simulated performance achieved an antenna gain of -3.4662 dBi, and an impedance bandwidth approximately 13.8MHz. Therefore, a compact high-gain antenna with a large bandwidth was achieved. This work investigates several problems for a printed dipole of arbitrary length embedded in MATLAB tool.

Keywords: Hilbert Curve Space-Filling Antennas(HCSFA), Implantable Medical Devices (IMDs), Dental, Dental, Dielectric constantetc.

I. INTRODUCTION

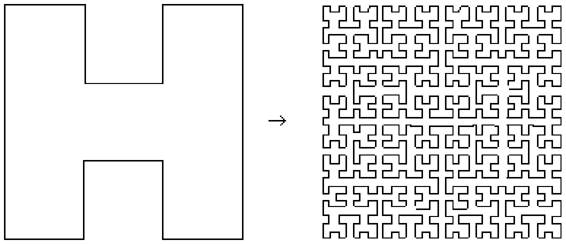
This paper focus on the implantable medical devices (IMDs) for dental antenna. It is one of the most significant innovative healthcare systems. Nowadays, the medical devices which are considered to monitor Biological data from inside the human body have great promises to provide main contributions to disease prevention, diagnosis and therapy thus reducing hospitalization terms and improving the patient's quality of life. It is accepted that modern antenna equipment will play an important role in the biomedical application. Important elements of implantable devices are antenna embedded in system contains Biosensors and interface circuits, which enable the exchange of data between implantable devices and external environment.

This implantable antenna is a combination of meander slots and square spiral slots have been embedded for effective size reduction at a fixed frequency operation. Compared to miniaturization of antennas the proposed antenna has advantages of good size reduction and also being easy to be optimized to the necessary resonance frequency. This design would fulfill the requirements of biocompatibility, miniaturization, patient safety, and high-quality communication with exterior equipment.

Hilbert Space-filling

The simple principle behind the Hilbert curve is slightly different from the constructions of exact replacements it looked at thus far. Instead of using a single standard shape to replace every line segment on every continuing level, the Hilbert curve applies various shapes or "rules" to different segments. This is known as a nonstandard construction. The Hilbert curve forms an elegant construction of patterns whose lines do not overlap.

H is for Hilbert



Level 1: Initial image **Level 2: Growth of initial**

Figure 1: The Hilbert curve's stages of growth

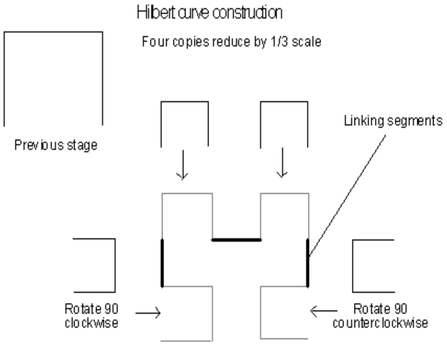


Figure 2: The Hilbert curve's construction.

In the Figure 2 given above, there are four component slinked together with three lines parts. This construction is the basis for the standard Hilbert curves each component usages the same construction to produce smaller sub sections. Carried out ad infinitum, this construction forms the Hilbert curve. As the curve goes to higher and higher levels, the links between component parts get correspondingly shorter.

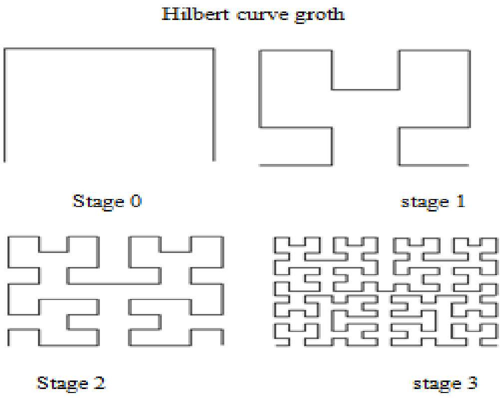


Figure 3: An alternative Hilbert curve, which is both closed and connected

An attractive attribute for the Hilbert curve is that principles, similar to the ones used in assembling the "plane filling" curve can be improved to fill a volumetric space see figure below.

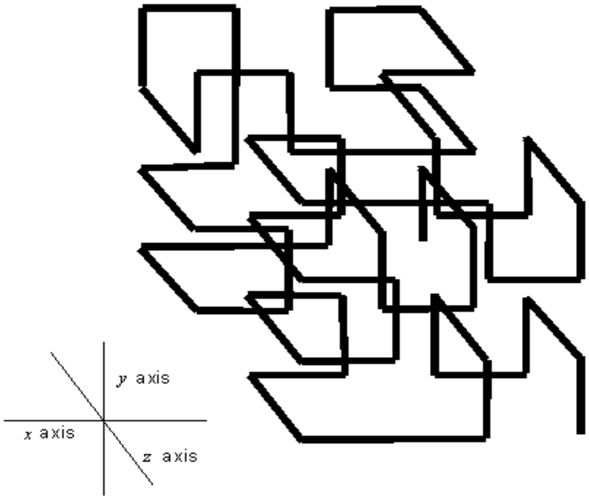


Figure 4: The 3D model of the Hilbert curve.

II SYSTEM MODEL

This system model modeled about Hilbert's space-filling curve and some of its properties that need. For more background, there is the monograph Sagan (1994) on space-filling curves, describes Hilbert's curve. Zumbusch (2003) describes multilevel numerical methods, including space- filling curves. Throughout this paper, d is a positive integer, λ_d is d-dimensional Lebesgue measure, and II.II is the usual Euclidean norm. For integer m ≥ 0, define 2^{dm} intervals

$$I_d^m(k) = [k/2^{dm},k+1/2^{dm}] , \quad k=0,\ldots\ldots, 2^{dm-1} \ldots 1$$

$$I_d^m=\{ I_d^m (k) \mid k< 2^{dm} \} . \ldots\ldots 2$$

and let $I_d^m=\{ I_d^m (k) \mid k< 2^{dm} \}$.Next, for k= $(k_1,\ldots\ldots k_d)$ with kj∈ {0, 1, . . . , 2 m − 1} define 2^{dm} sub cubes of $[0, 1]^d$ via

$$E_d^m(k)= \Pi^d_{j=1}[k_{j/2}^{m,} k_{j+1/2}^{m} \ldots\ldots 3$$

The set of indices κ is $K^m_d = \{0, 1 . . . 2^m - 1\}^d$ and let $E^m_d = \{E^m_d (\kappa) \mid \kappa \in K^m_d \}$. One can find a sequence of mappings H_m: $I_d^m \rightarrow \varepsilon_d^m$ with the following properties,

•Bijection: for

$$k \neq k', H_m(I_d^m(k)) \neq H_m(I_d^m(k')) \ldots\ldots 4$$

• Adjacency: The two sub cubes$H_m(I_d^m(k))$ and $H_m(I_d^m(k+1))$ are adjacent. That is, they have one (d − 1)-dimensional face in common.

• Nesting: If it split I^m_d (k) into the 2^d successive subintervals I^{m+1}_d (k_l), $k_l = 2^d k+l, l = 0, \ldots, 2^d-1$, then the $H_{m+1}(I^{m+1}_d (k_l))$ are sub cubes whose union is $H_m(I^m_d (k))$.

Figure 5 illustrates the Hilbert curve construction in dimension 2

The Hilbert curve is defined by H(x) = limm→∞ $H_m(x)$. The point x ∈ [0, 1] belongs to an infinite sequence $I^m_d (k_m)$ of intervals which shrink to x. If x does not have a terminating base 2 representation then the sequence $I^m_d (k_m)$ is unique and then H_m(I m d (km)) is a unique sequence of sub cubes.

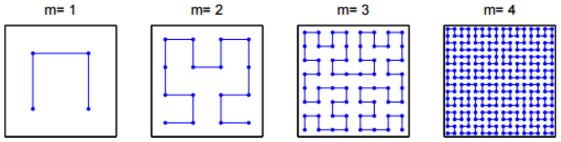


Figure 5: First 4 stages in the approximation of Hilbert's space-filling curve

Points such as x = 1/4 = 0.010 = 0.001 with two binary representations nevertheless have uniquely defined H(x). The Hilbert curve passes through every point in $[0, 1]^d$. It is not surjective: there are points x is not equal to with H(x) = H(x'). Indeed, a result of Netto (1879) shows that no space-filling curve from [0, 1] to $[0, 1]^d$ ford> 1 can be bijective.

There is more than one way to define the sequence of |mappings in a Hilbert curve. But any of those ways produces a mapping H with these properties:

- P (1): $H (I_d^m(k)) = H_m(I_d^m(k))$.
- P (2): If Ac[0, 1] is measurable, then $\lambda_1(A)$= (H (A)).
- P (3): if x~U ([0, 1]) then H (x) ~ $U([0,1]^d)$. It admits the change of variables.

It admits the change of variables:

$$\mu = \int_{[0,1]}^{d\, f(x)\, dx} = \int_0^1 f(H(x))\, dx \ldots\ldots\ldots\ldots\ldots\ldots\ldots 5$$

• P(4): The function H(x) is H¨older continuous, but nowhere differentiable. More precisely, for any x, y ∈ [0, 1],

$$||Hx - H(y)|| <= 2 \frac{\sqrt{d+3}}{x-y} 1/d \ldots\ldots\ldots\ldots\ldots\ldots \mathbf{6}$$

The Holder property P(4) is proved in Zumbusch (2003).

III PROPOSED METHOD

As this method using in space filling Hilbert(***HCSFA***) based antenna is Self-affine sets form an important class of sets, which contain self-similar sets as a particular case. An affine transformation S: n n$\Re \rightarrow \Re$ is a transformation of the form

$$W(x, y) = T(x, y) + t \ldots\ldots\ldots\ldots 7$$

Where T is a linear transformation on n ℜ (which may be signified by an n x n matrix) and t is a vector in n ℜ . Thus an affine transformation w is a grouping of a translation, rotation, dilation and, possibly reflection If w1,…,wm are self-affine contractions on n ℜ , the unique compact invariant set F for the wi is termed a self-affine set.

w1, w2 and w3 are well-defined as the alterations that map the line part onto the three line segments in the obvious way. It is obviously to look for a formula for the dimension of self-affine sets that generalizes formula for self-similar sets.

The dimension depends on the affine transformations in a reasonably simple way, easily expressible in terms of the matrices, and vectors that represent the affine transformation.

Iterated Function Systems (IFS):

These iterated function systems are based on the application of a series of affine transformations, w, define by

$$w\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} a & b \\ c & d \end{pmatrix}\begin{pmatrix} x \\ y \end{pmatrix} + \begin{pmatrix} e \\ f \end{pmatrix} \ldots\ldots\ldots\ldots\ldots\ldots 8$$

Or, equivalent, by

$$W(x,y) = (ax + by + e, cx + dy + f), \ldots\ldots\ldots 9$$

where real number coefficients (a, b, c, d, e, f) are responsible for movement of fractal element in space: a, d - scaling, b, c – rotation by φ1 , φ2 angles with respect to axis of coordinating system, and e, f – linear translation by the vector (e, f) , respectively.

Simulation Table:

The following table shows the simulated input & variable for different feeding locations.

INPUT	VALUES
width	10.5 mm
length	7 mm
Height	7 mm
Z_rO_2	($\varepsilon r = 21$)
Environment Model	Human Oral Cavity
Bandwidth(MHz)	13.8

Table 1: Simulation Parameter Table

IV RESULT ANALYSIS

By using Hilbert space filling curve achieved which is resonant at,in this case the measured radiation pattern varies are -24.21 to 27.7 dBiat theta 90 degree respectively.Based on simulation results,It will clearly see the effect of changing h and εr on antenna dimensions and performance but also its radiation patterns and other parameters such as its directivity, which will help them understand the working of the patch better.

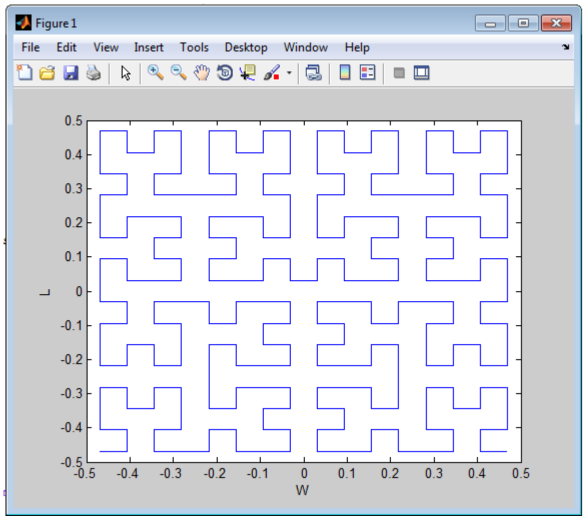


Figure 6: design of simple space filling curve

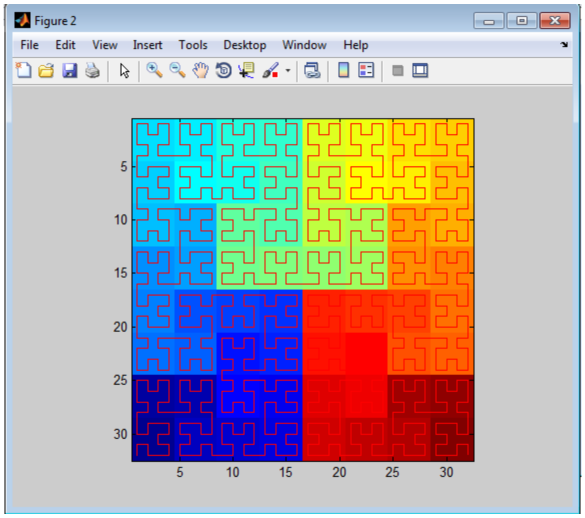


Figure 7: Design of space filling curve divided in sub-block of 4*4 matrixes

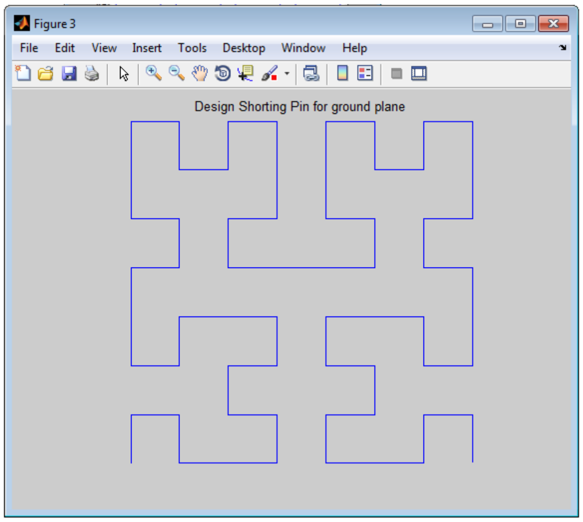


Figure 8: design of shorting pin for ground plane in space filling curve

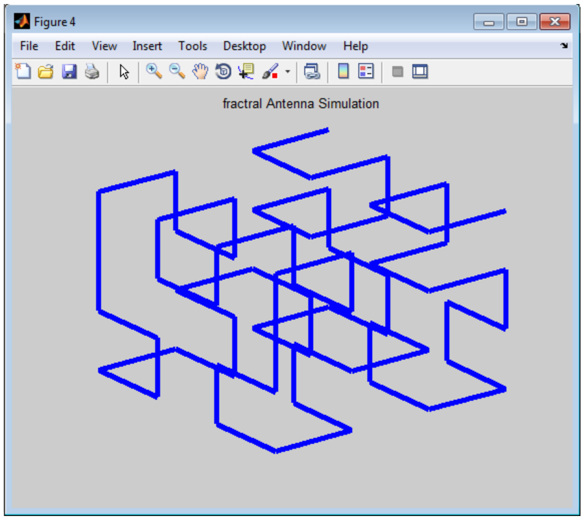


Figure 9: design of 3-D fractals Antenna in space filling curve

By using fractal antenna, that can identify approximation value of x and y respectively check and manipulate in resonant factor, another benefit utilize the width and turn around azimuth angle theta=90 degree.

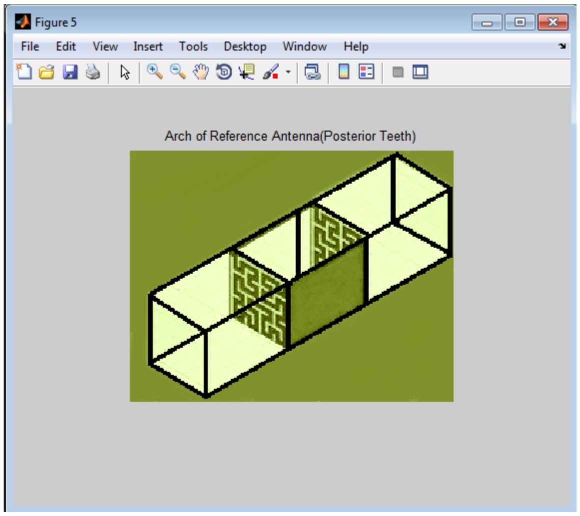


Figure 10: design for reference Antenna for posterior teeth.

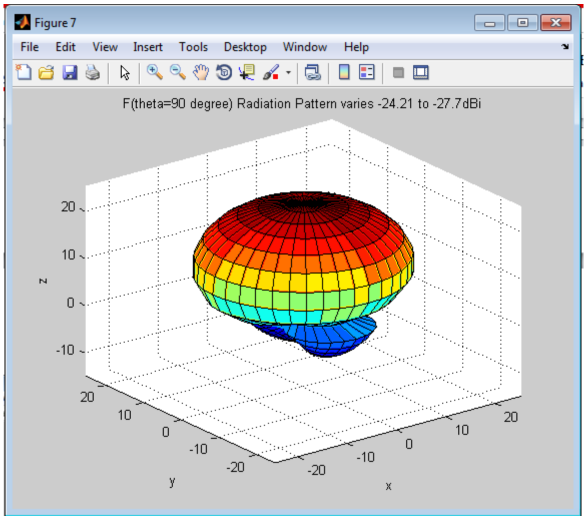


Figure 11: showing 3-D plot for radiation pattern at dBi .

To simulate the operation of ***HCSFA*** in based on an MATLAB human body model and simulation study was based on the properties and parameters obtained after the ceramic process that improving the radiation pattern variation

V. CONCLUSION

The investigation on the performance of Hilbert curve based fractal implantable antennas *HCSFA*have been carried out in this work using numerical simulations**.** The objective of design and simulation of *HCSFA*(Hilbert curve space filling) for obtaining better performances has been satisfactorily noticed with the simulation results. The performances of the Hilbert curve space filling by using IFS function areappreciable in terms of more resonant frequencies directivity and shaped radiation. This is because of the existence of the negative ε and negative µ properties in the prepared material.

The future work would be to make efforts for further improving the return loss , gain and some desired parameter at measured equation in human oral cavity with Archimedean spirals to create a minimally invasive implantable device for remote health care applications.

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Rohit Kumar Balyan, received the B.tech degree in electronics and communication engineering from Sunderdeep engineering college ghaziabad, GBTU, in 2013. He is persuingM.Tech in electronics and communication engineering from Ajay Kumar Garg Engineering College, UPTU, from 2013. He completed his engineering with 72.18% and his area of interest is implantable antennas used in bio-medical field.

Richareceived the B.Tech, M.Tech degree with Honors in Electronics and Communication Engineering from SantLongowal Institute of Engineering and Technology, Longowal, Punjab. Presently she is working as Assistant Professor in Electronics & Communication Engineering Department of Ajay Kumar Garg Engineering College, Ghaziabad, Uttar Pradesh, India. She has successfully published more than 15 international review and research papers and also presented research papers in international conferences. Her area of research field includes Communication, Antennas and Propagation.