Improvement on the Invalidation in NURBS MOM-PO Method

Kai Huang [1], Zhi-Li He [1], #Xun-Wang Zhao [1], Chang-Hong Liang [1], Hang Su [2]
[1] School of Electronic Engineering, Xidian University
Xi'an, 710071, Shaanxi, China, huangkai841025@126.com
[2] School of Information Science and Engineering, Lanzhou University
No.222 South Tianshui Road, Lanzhou 730000, China, cherry19893141@hotmail.com

1. Introduction

In 1992, J. Perez [1] first introduced the NURBS surface modeling technology into the field of high frequency electromagnetic computation. This technology has many advantages, such as high in modeling precision, few in the number of surfaces and so on. Therefore, electromagnetic computational methods based on NURBS modeling [2-5] have been widely analyzed since 1992. In 2007, MOM-PO was utilized to calculate the disturbed radiation pattern of antenna around a platform modeled by NURBS surfaces by Ming Chen [5] etc., and satisfying effects were obtained.

In the last part of Ref. [5], however, it is pointed out that "One important issue is how to deal with cases when antenna is very close (less than one wavelength) or even connected to the platform.", which implies that the method is invalid when the distance between antenna and scatterer is less than one wavelength. By careful analysis, we have found that the invalidation is resulted from the SPM used in [5]. In fact, SPM is invalid in the computation of near field, and this invalidation leads to the incorrect impedance matrix element, and then to the wrong current distribution over the antenna, which is obtained by modifying the impedance matrix. In order to recover this invalidation, we attempt to calculate the scattered field in near field region by using Ludwig integral instead of the SPM. It is found that the validity and accuracy of this method are reasonable whether the distance from antenna to surface is less than one wavelength or not.

2. Theory

The key point of this theory is the calculation of the physical optical scattered fields taking the dipole as the source, as shown in fig.1.

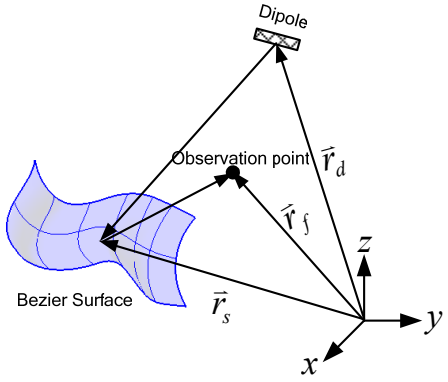

Figure1: NURBS-PO scattered field when illuminated by a dipole

As presented in [5], the PO scattered field is expressed as：

$$\vec{E}^{PO} = \frac{-d}{16 j\omega\varepsilon\pi^2}\int_0^1\int_0^1 \vec{g}(u,v)e^{jkf(u,v)}dudv \tag{1}$$

where

$$f(u,v) = -\left(R_{sd} + R_{fs}\right) \tag{2}$$

and

$$\vec{g}(u,v) = \left\{\frac{3-k^2R_{fs}^2 + j3kR_{fs}}{R_{fs}^5}\vec{R}_{fs}\times\left(\vec{R}_{fs}\times 2\hat{n}\times\left(\vec{R}_{sd}\times\vec{g}_n\right)\right)\right.$$
$$\left. + \frac{4\left(1+jkR_{fs}\right)}{R_{fs}^3}\left(\hat{n}\times\left(\vec{R}_{sd}\times\vec{g}_n\right)\right)\right\}\frac{(1+jkR_{sd})}{R_{sd}^3}\left|\vec{r}_{su}\times\vec{r}_{sv}\right| \tag{3}$$

It was presented that this integral can be computed by SPM when $k >> 1$ in [5]. Actually, the condition under which SPM is applicable is that the exponential part of the integrand should be much more than 1. When the action of the scattered field on the MOM element is implemented, R_{sd}, the distance of the antenna to the scatterer, is almost equal to R_{fs}. Therefore, when R_{sd} is small, the exponential part of the integrand in equation (1)

$$k\left|f(u,v)\right| = k\left|-\left(R_{sd}+R_{fs}\right)\right| = \frac{2\pi}{\lambda}\left|-\left(R_{sd}+R_{fs}\right)\right| \tag{4}$$

couldn't satisfy the condition. It directly results in the incorrect impedance matrix element, and then the wrong current distribution. Based on the analysis above and with a hope of improving the invalidation, we attempt to calculate the scattered field in near field by using Ludwig integral instead of the SPM. The method of Ludwig integral were discussed in detail in [6,7].

3. Numerical results

The model in [5] is calculated by the present method at first. The modal of the spherical surface is shown in fig.3, the radius of which is 0.2m. The antenna whose length is 0.5 λ and working frequency 3GHz, is centered on (0.21213,0.21213,0.0), and placed 1 λ away from the surface. The result of the disturbed radiation pattern in the plane of $\phi = 45°$ under spherical coordinates is compared with that in [5] as shown in fig.4, which shows good agreement with each other. This demonstrates that the present method is applicable when the SPM is valid.

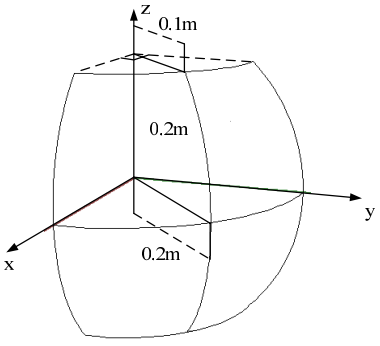

Figure 3 .Spherical surface

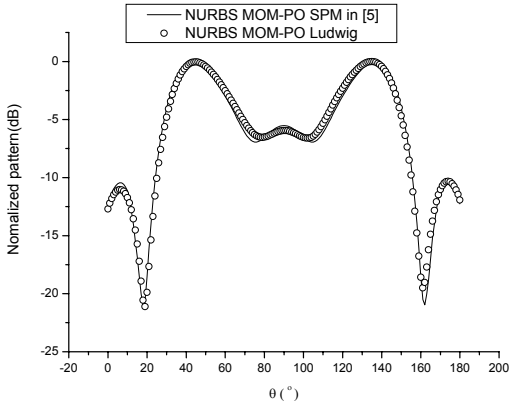

Fig. 4. Radiation pattern of $\varphi = 45^{\circ}$ plane with antenna's position (0.21213, 0.21213, 0.0).

Now, the same model is further analyzed when the center of the antenna is moved to (0.17678, 0.17678, 0.0), hence the distance of the antenna to the surface is 0.5λ. The calculated result of the disturbed radiation pattern in the plane of $\phi = 45°$ is compared with that obtained from NURBS MOM-PO SPM method in [5] and that from pure MOM, as shown in fig.5. It's obvious to see that the result of the present method agrees very well with that of MOM, whereas SPM is invalid indeed. Therefore, the present approach is very useful for obtaining accurate results without restrictions on the distance between the antenna and the surface.

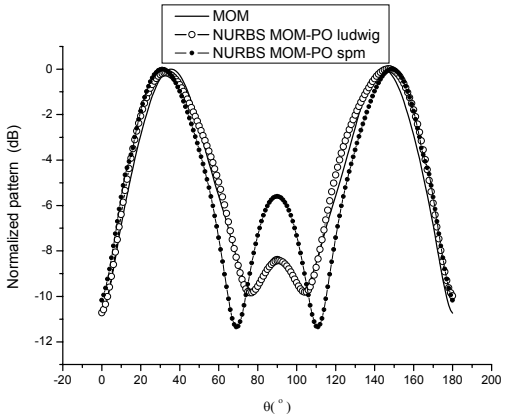

Fig.5. Radiation pattern of $\varphi = 45^{\circ}$ plane with antenna's position (0.17678, 0.17678, 0.0)

4. Conclusion

In this paper, the reason of the invalidation in the method of MOM-PO based on the NURBS modeling, which occurs when the distance between antenna and scatterer is less than one wavelength, is analyzed in detail. The problem is solved by using Ludwig integral to calculate the integral of PO currents. The comparison of the results obtained by this method and the ones in literatures and MOM shows the feasibility and accuracy of the present method.

References

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