식물학에서의 확산텐서영상 이용

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The New Usage of Diffusion Tensor Imaging in Botany

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ABSTRACT

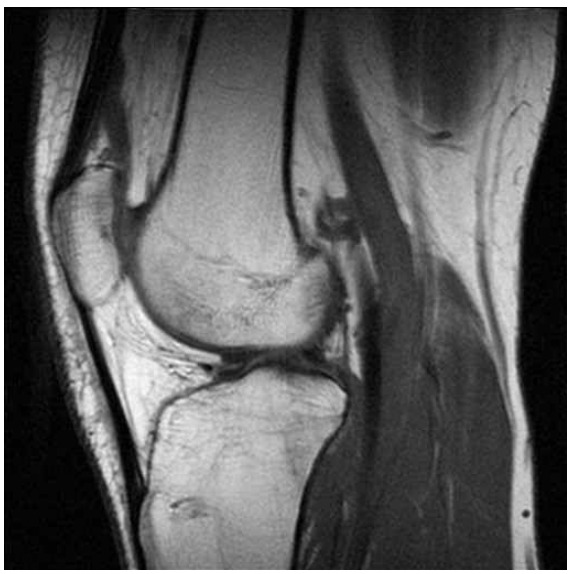
This paper explains what DTI (Diffusion Tensor Imaging) is and what it does. We will talk about the DTI functions and what type of image it can show, and what areas are using DTI. The tractography and other applications that DTI is being used. In this paper, we explain that DTI is not only useful in medicine but also in botany. We propose to use DTI to study structure and functions of plants.

1. Introduction

In botany, optical and electron microscope are commonly used to study plant cellular structure. Optical microscope uses visible light and carefully layered lenses to magnify the target up to 2000x magnification which is enough to study some plants in cellular level. But to learn the cellular structure in plants more accurately in higher magnification. There comes electron microscope where the magnification can reach up to 1.000.000x. It uses electrons with wavelength about 100.000 times shorter than visible light. The contribution of microscopes for the science is immense, and the uses of microscopes are continues. Our study for knowledge grows, and our method and tool gets even more sophisticated.

2. Magnetic Resonance Imaging

Unlike X-ray, MRI doesn't radiate ions. Instead, it causes the hydrogen nuclei to produce a rotating magnetic field and scan it. To do so, it uses strong magnetic field. Magnetic resonance imaging (MRI) is primarily used neurological (brain), musculoskeletal, cardiovascular, and oncological (cancer) imaging due to its high contrast between different soft tissues of the body, and non-invasive scanning. But it does not



[fig 1] MR image of knee [2]

이 논문은 교육과학기술부의 재원으로 한국연구재단의 지원을 받아 수행된 연구임(세계수준의 연구중심대학 육성사업, R31-2008-000-10069-0)

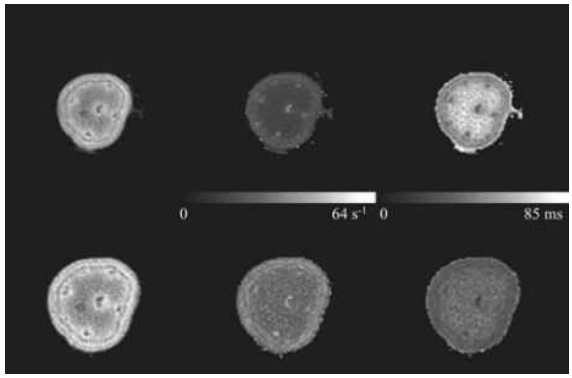
mean MRI should only be used on delicate targets. Peter Blümler, Carel W. Windt, and Dagmar van Dusschoten of the Research Centre Jülich already did a research and successfully scanned 3D image of maize root system. According to the paper, it was no simple task, and to produce meaningful data MRI of plants requires plants as living system (illumination, climate control, etc) and the even hardware should to optimized for it.

3. MRI Contrast Agents

MRI Contrast Agents are substances used to improve MRI images. Gadolinium is toxic, so Gadolinium atom containing molecules are commonly used as contrast agents. Omniscan (Gadodiamide) Magnevist (Gadopentetate dimeglumine) MultiHance (Gadobenate dimeglumine) Gadovist (Gadobutrol) Vasovist (Gadofosveset) Dotarem (Gadoteric acid) ProHance (Gadoteridol) Primovist are all contrast agents containing Gadolinium. Many of the contrast agents improve the MRI by altering T1 or T2 relaxation time of protons.

4. Advantages of proposed method

Earlier versions of MRI unit required patients to stay still for 40 minutes which is not easy for patients. However, plants can stay still as long as the machine wants without complaints. Compared to human and animal body where heart constantly beats, plants barely ever moves. It ensures higher quality images with greater resolution. It means the sub-cellular level 3D images are possible. The long term images (video) can last for days providing us the information how the minerals spread and how the plant function in 3D. One of the main safety issues with MRI is metal implants inside patients or other metal objects. Plants usually do not have metal implants and even if there were metal objects lying in the plant it would not cause death to the plant. Because the damaged parts of the plant will just grow back. Plants are tougher than delicate human body. Plants body is much simpler than animal or human body, and internal structure is symmetric and easily make up polygons that produce 3D images.



[fig 2] Amplitude, 1/T2 and T2 micro-images of leave petiole of geranium measured with a small dedicated rf coil (i.d. 3 mm) at 0.7 T (30 MHz). Parameters: Df 25 kHz, TE 6.6 ms, 128 x 128 matrix, FOV 5 (first row) en 4 mm (second row) (resolution 39 x 39 x 2500 and 31 x 31 x 2,500 nano-m3, respectively), N av 6, TR 2.5s, 32 min total acquisition time. Sample image from [8].

5. Disadvantages

MRI tesla scanners are expensive. 1.5 tesla scanners cost between 1 to 1.5 million US dollars. and 3.0 tesla scanner costs 2 to 2.3 million US dollars. Even we had the money, the MRI tesla scanners are designed for human patients, so we need specialized hardware, custom modifications and optimizations for MRI equipments to take proper images of the plants.

6. MRI of Plants

The modern MRI tesla scanners have many new functions targeted for human patients including safety, comfortability, modifications. However, for MRI of plants many of these updates are not necessary, so we can use outdated models for imaging plants rather. These old tesla scanners need maintenance, so we can disassemble the scanner for maintenance and for modifying its hardware for scanning plants. It would be better than modifying brand new MRI tesla scanner just for imaging plants.

7. Conclusion

This paper introduced many advantages of the MRI of plants over disadvantages where disadvantages are only money and poor usage and development problems. However, in science, we should always consider what is truly important and should have higher priority for research. In my opinion, the study for neurology (brain), cancer and humans should have higher priority than plants. Even so, the MRI of plants should not be forgotten.

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