

CT voxel 3

## The Construction of Trunk Voxel Phantom by Using CT Images and Application to 3 Dimensional Radiotherapy Treatment Planning

CT voxel . CT NLM(National Library of Medicine) VHP(Visual Human Project) man CT MCNP4B  
 5cm 153 . CT  
 CT VHP man  
 가 voxel , , 3cm  
 5, 10, 15MeV  
 3 3

### ABSTRACT

Trunk voxel phantom was constructed by using whole body CT images and tumor doses were calculated by using Monte Carlo method after simulating situation of radiotherapy treatment planning. The whole body CT images of VHP(Visual Human Project) man were acquired from National Library of Medicine of USA. 153 slices of trunk part were extracted from whole body CT images and MCNP4B, a general purpose Monte Carlo code, was used for dose calculation. Gray scale of CT images were converted into density of medium and processed into trunk voxel phantom ported to MCNP4B input deck. The conversion method was verified by comparing cross sectional images of voxel phantom with original CT images. Tumor volumes with diameter of 3cm were defined in liver, stomach and right lung and irradiated with 5, 10 and 15 MeV gamma beam with diameter of 6cm. The technical basis for 3D dose calculation was established through this study for localization of 3D RTP system.

1.

가

2

. CT MRI

[1]. 3

3

CT (gray scale)가

[2]. CT

voxel

가 가

2.

CT

NLM(National Library of Medicine) VHP(Visible Human Project)

CT [3]. NLM

186cm, 90kg 38 1mm

, CT MR ( 1).

JPEG CT 5cm 153

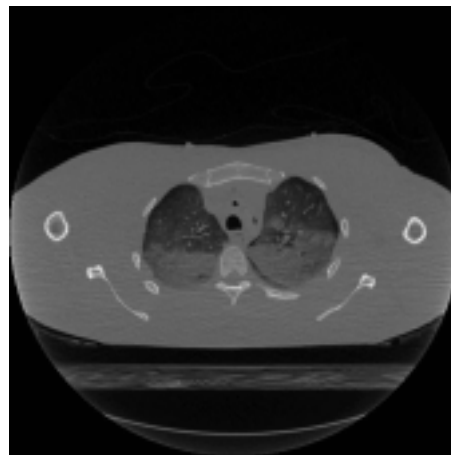
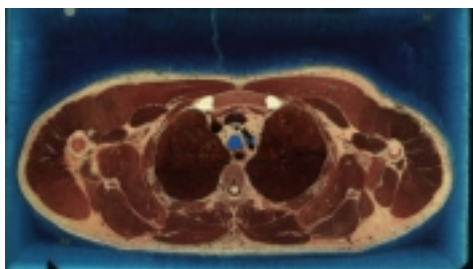


Figure 1. Color cross section photo(left) and CT image(right) of VHP man.

CT . 0 256  
 Alfdi  
 1 GE9800 CT [4].  
 가 CT#(-1000~1000) 가  
 CT JPEG (0~256)  
 ICRP23[5] ICRU44[6]  
 6가 , , , , 가 . JPEG  
 CT (binary)  
 MCNP4B

Table 1. Element breakdown and gray scale range for the 5 primary tissues.

	Lung	Fat	Water	Muscle	Bone
CT gray scale	9~103	103~127	127~129	129~164	164~256
Density range	0.05~0.65	0.85~0.98	1.00	1.06~1.26	1.48~2.10
H(Z=1)	10.3	11.4	11.1	10.2	3.4
C(Z=6)	10.5	59.8		14.3	15.5
N(Z=7)	3.1	0.7		3.4	4.2
O(Z=8)	74.9	27.8	88.9	71.0	43.5
Na(Z=11)	0.2	0.1		0.1	0.1
Mg(Z=12)					0.2
P(Z=15)	0.2			0.2	10.3
S(Z=16)	0.3	0.1		0.3	0.3
Cl(Z=17)	0.3	0.1		0.1	
K(Z=19)	0.2			0.4	
Ca(Z=20)					22.5

Voxel  
 MCNP4B  
 4B [7].  
 voxel MCNP4B ENDF  
 . MCNP4B (repeated structure algorithm) voxel  
 3 voxel  
 300,000

3.

voxel

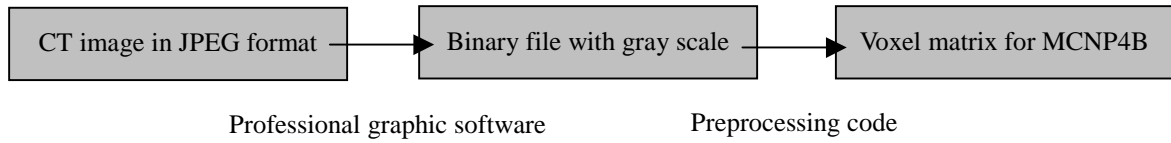


Figure2. Flow diagram of data processing for MCNP4B input file.

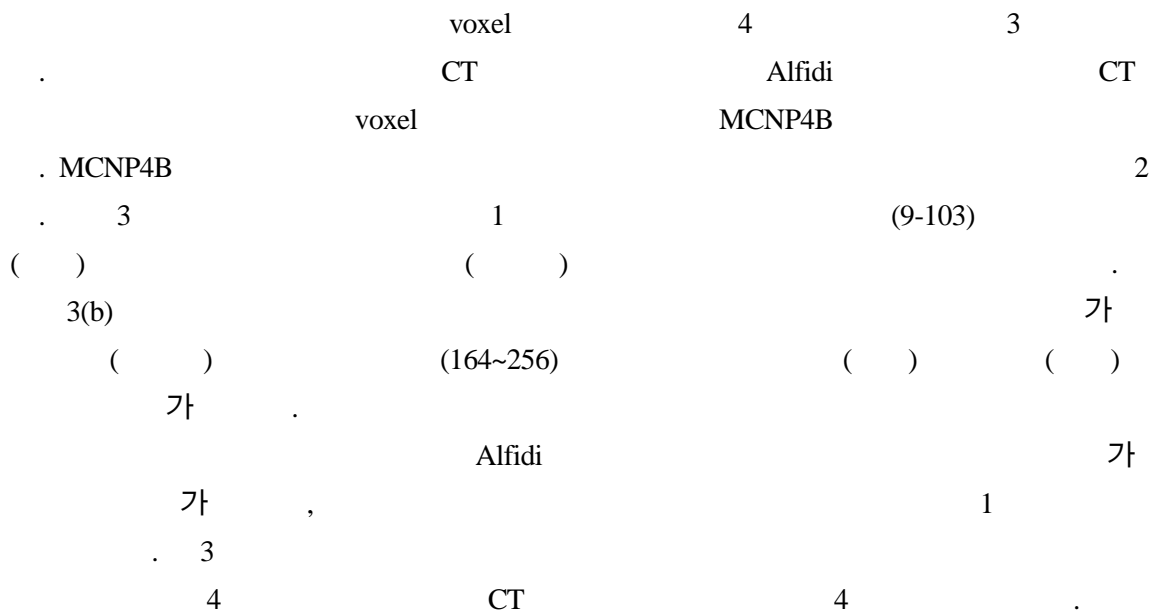
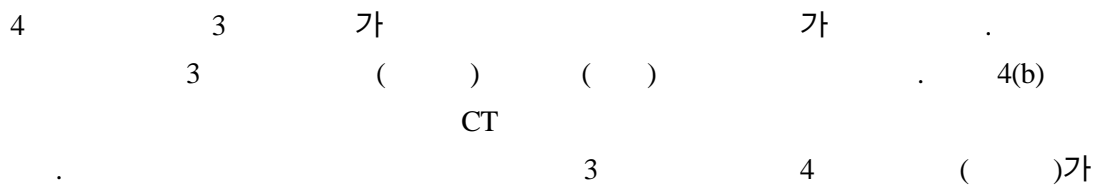


Table2. Color indexes, cell number and its material for MCNP4B.

	Cell number	Material
Pink	10	Air
Blue	20	Lung
Green	30	Fat
Yellow	40	Water
Gray	50	Muscle
Sky blue	60	Bone
Orange	70	Tumor



voxel y=0 voxel x=0  
 5 5(a) (b)  
 CT  
 가

Table3. Modified range of gray scale.

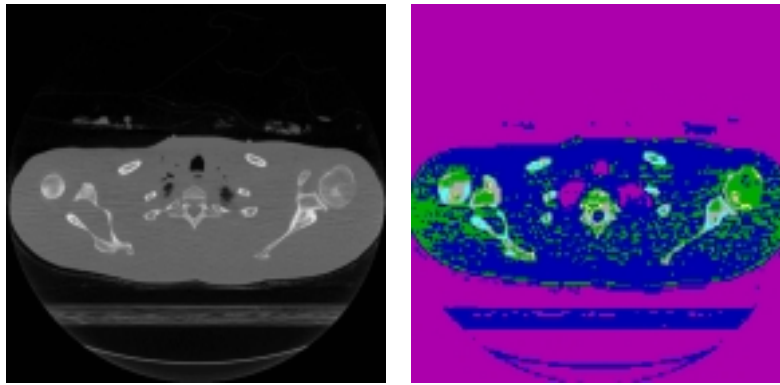
	Lung	Fat	Water	Muscle	Bone
CT gray scale	40~80	80~90	90~100	100~130	130~256
Density range	0.05~0.65	0.85~0.98	1.00	1.06~1.26	1.48~2.10

voxel , , 3cm  
 6  
 10, 15MeV 6cm ( 4). 5,

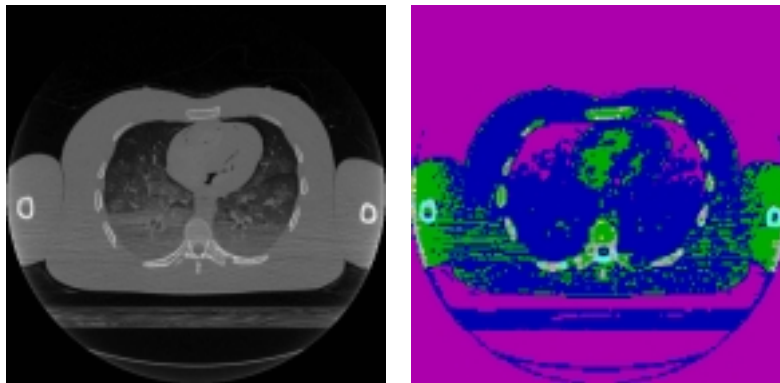
Table4. Tumor dose(Sv) for lung, liver, stomach irradiated by 5, 10 and 15MeV gamma beam with diameter, 4cm.

	Lung	Liver	Stomach
5MeV	6.96240E-12	7.13974E-12	7.12573E-12
10MeV	1.25890E-11	1.28119E-11	1.27838E-11
15MeV	1.80758E-11	1.83081E-11	1.82910E-11

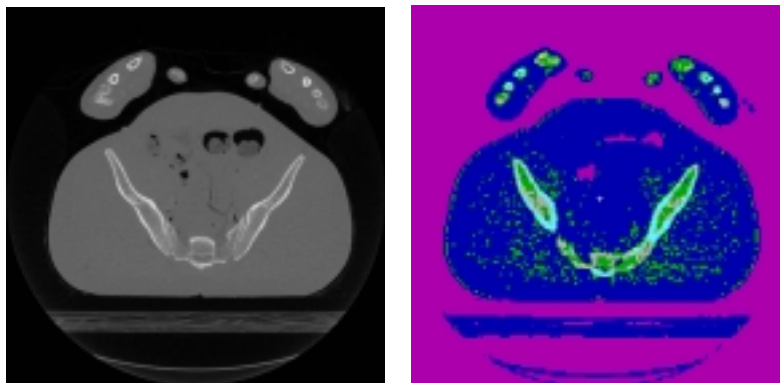
4 가  
 y 가 48 z  
 x (x=-10, x=10) 가  
 가  
 가



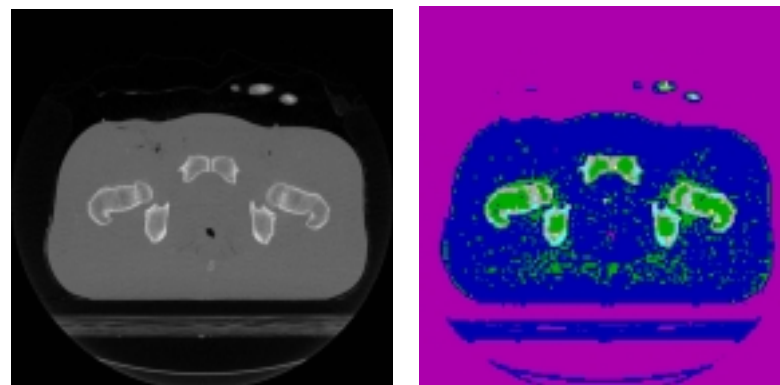
(a) 7<sup>th</sup> slice



(b) 36<sup>th</sup> slice

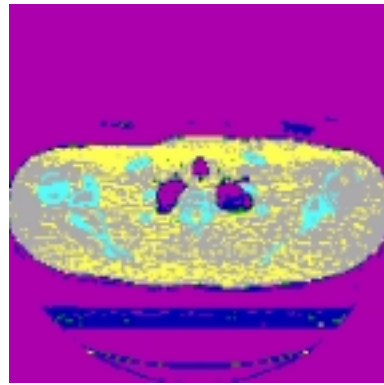
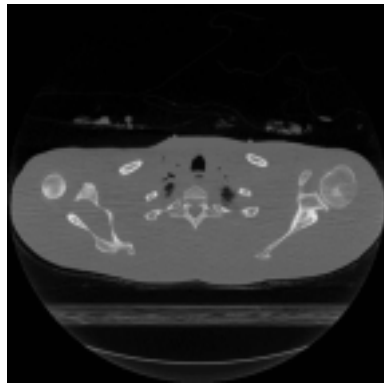


(c) 110<sup>th</sup> slice

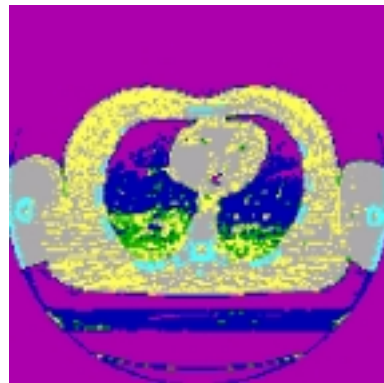
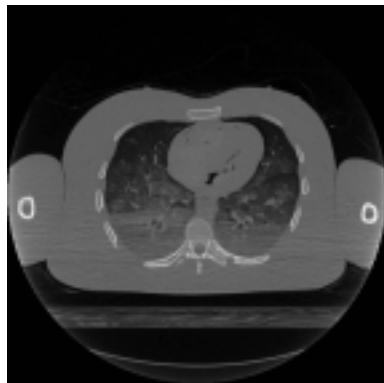


(d) 125<sup>th</sup> slice

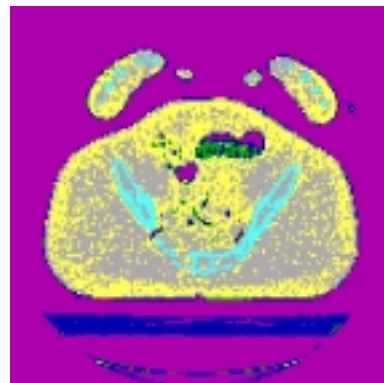
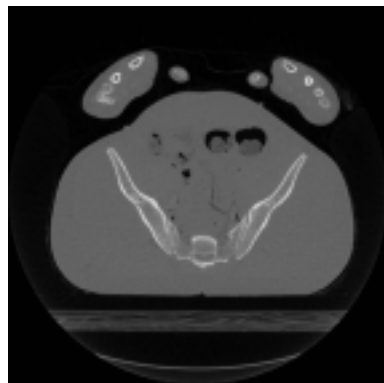
Figure3. Comparison between original CT images(left) and converted voxel slice(right) by Alfidi's range(right)



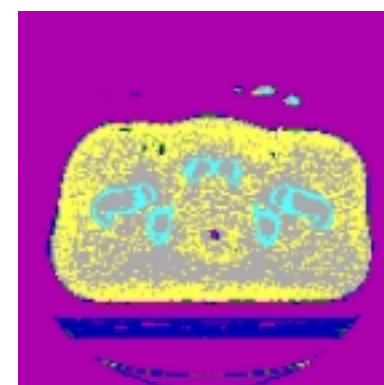
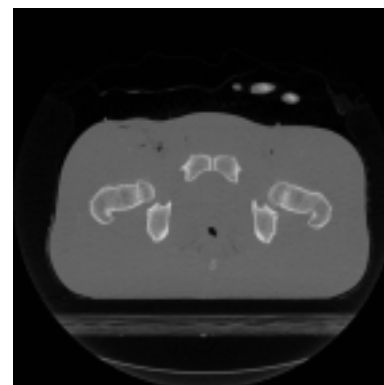
(d) 7<sup>th</sup> slice



(e) 36<sup>th</sup> slice

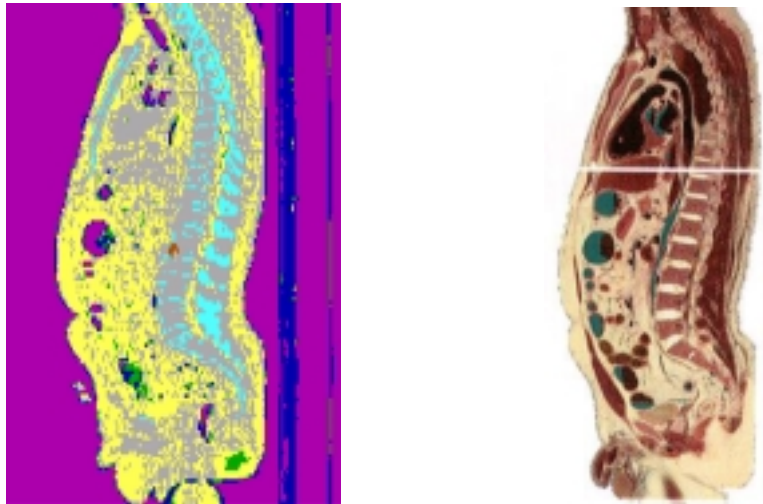


(f) 110<sup>th</sup> slice

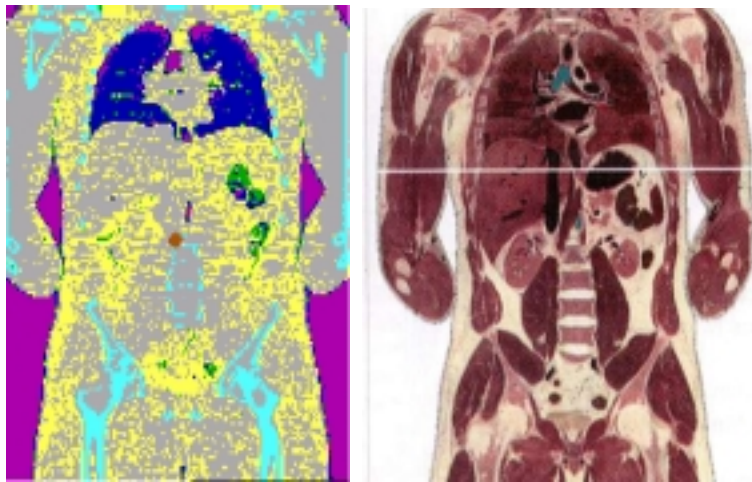


(d) 125<sup>th</sup> slice

Figure4. Comparison between original CT images(left) and converted voxel slice(right) by modified range(right)

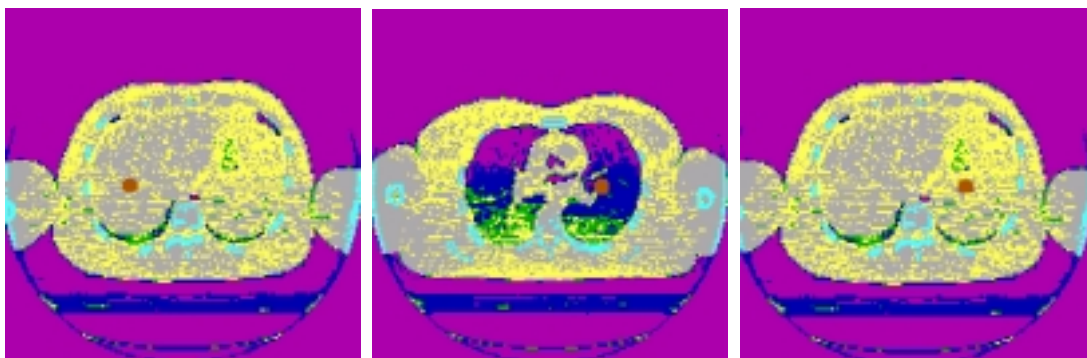


(a) Sagittal view at  $x=0$  plane.



(a) Coronal view at  $y=0$  plane

Figure5. Sagittal and coronal view of voxel phantom(left) and VHP man(right).



(a) Liver ( $x=-10, y=0, 48^{\text{th}}$  slice)

(b) Lung ( $x=10, y=0, 33^{\text{th}}$  slice)

(c) Stomach ( $x=10, y=0, 48^{\text{th}}$  slice)

Figure6. Position of tumor volume in (a) liver, (b) lung and (c) stomach.



4.

CT voxel . VHP man CT  
153 MCNP4B . CT  
man 가 CT VHP  
3cm 5, 10, 15MeV , ,  
가 가  
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CT voxel 3

5.

- [1] Alfred R. Smith, Radiation Therapy Physics, Springer-Verlag Berlin Heidelberg (1995)
- [2] J.J. Demarco, T.D. Solberg, J.B. Smathers, A CT-based Monte Carlo simulation tool for dosimetry planning and analysis, Med. Phys. 25(1) (1998)
- [3] Victor M. Spitzer, David G. Whitlock, Atlas of the Visible Human Male, pp. xi-xvii, Jones and Bartlett Publishers, London (1998)
- [4] R.J. Alfidi, W.J. MacIntyre, T.F. Meaney, E.S. Chernak, P. Janicki, R. Tarar, and H. Levin, "Experimental studies to determine application of CAT scanning to the human body", Radiology 124, 199 (1975)
- [5] ICRP Publication 23, Report of the Task Group on Reference Man (1975)
- [6] ICRU Report 44, Tissue Substitutes in Radiation Dosimetry and Measurement (1989)
- [7] LANL Group X-6, MCNP-A General Monte Carlo Code N-Particle Transport Code Version 4B, LA-12625-M (1997)