Engine for brain development: Similarity between engine and brain

H. Kawanobe and K. Naitoh

Waseda University, Faculty of Science and Engineering, 3-4-1 Ookubo, Shinjuku, Tokyo, 169-8555 Japan
(Tel : 81-3-5286-3265)
(Email address:k-naito@waseda.jp)

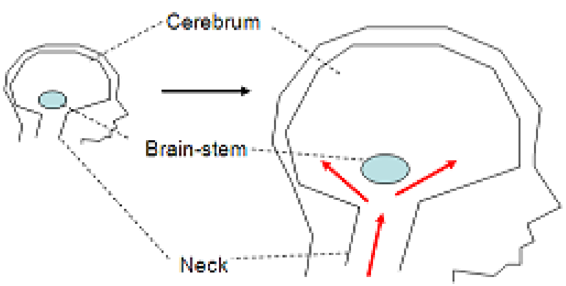
Abstract: Observations of the development of the human brain show the bones of the skull become increasingly larger over the neck, and a lot of soup like fluid for generating brain cells enters the skull from the body. This process is essentially similar to the intake process of an internal combustion engine and also that the soup for generating flexible brain cells can be essentially modeled by using the Navier-Stokes equation. The flow of air during the intake process of a piston engine and fluid flow in the brain, including water as the main component, can be approximated as being incompressible. In this report, we will examine the spatial patterns of convexoconcave of brain and blood vessels in details.

Keywords: Brain shape, Blood vessels, Morphogenesis, Engine, Fluid dynamics

I. CEREBRAL DEVELOPMENT [1]

Observations of the development of the human brain with a high-speed camera reveal that the bones of the skull become increasingly larger over the neck, and a lot of soup-like fluid for generating flexible cells, including nerves and synapses, enters the skull from the body.

(a) Brain volume increasing



(b) Volume increasing during the intake process of a piston engine

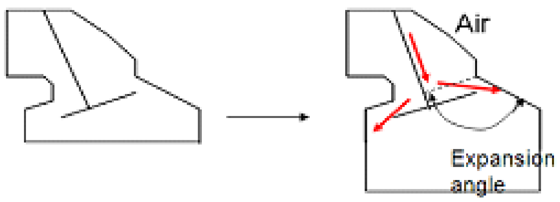


Fig.1 Topological similarity of the brain and an engine[1]

This process is essentially similar to the intake process of an internal combustion engine, because the volume of an engine cylinder, which increases according to the descent of the piston, corresponds geometrically to the development of the skull, and also because the human neck looks like the intake port that functions as the throat of an engine (Fig.1).

The soup for generating flexible brain cells can be essentially modeled by using the fluid dynamics for flow in an engine. The flow of air during the intake process of a piston engine and fluid flow in the brain, including water as the main component, can be approximated as being incompressible. (The intake process of an engine at low engine speeds is incompressible, although the compression process is strongly compressible with time using the zero-Mach number regime.) [2,3]

II. NAVIER-STOKES EQUATION [1]

We employ the incompressible Navier-Stokes equation [4] as the basic governing equation that describes the flexible dynamic motion of a lot of soup-like fluid for generating brain cells. [1-3] The equation can be written as

$$\frac{\partial u_i}{\partial t}+\sum_j u_j\frac{\partial u_i}{\partial x_j}=-\frac{1}{\rho}\frac{\partial p}{\partial x_i}+\nu\sum_j\frac{\partial^2 u_i}{\partial x_j^2}$$

$$\sum_i\frac{\partial u_i}{\partial x_i}=0 \qquad (1)$$

where u_i, ρ, p, and ν denote the fluid velocity, fluid density, pressure, and kinetic viscosity coefficient, respectively, while x_i (i=1,2,3) denotes Cartesian coordinates in three dimensional space. Equation 1 is computed by the finite difference method using a higher order of accuracy. [1,2,3] The details of the computational method are given in the references.

III. COMPUTATIONAL RESULTS

Figure 2a shows an image of the human brain obtained with magnetic resonance imaging (MRI) at a horizontal cross section including the two eyes, while Fig.2b is the result of the corresponding computation performed with the Navier-Stokes equation. Red lines in Fig. 2 show that the convexoconcave shapes inside the brain are similar to the flow structure in engine.

(a) (b)

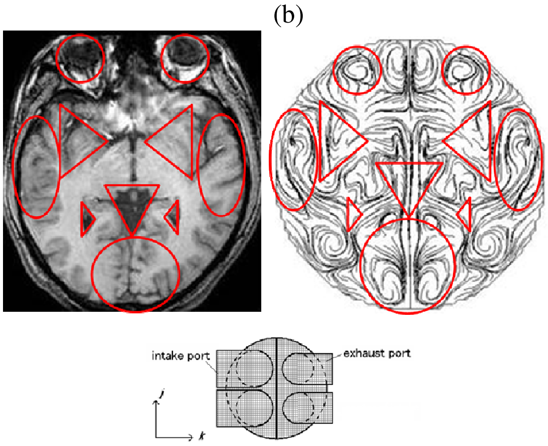


Fig.2 Comparison of brain MRI and engine flow (j-k cross section)
(a) Magnetic resonance imaging (MRI) of brain [5]
(b) Computational result at an engine speed of 1400 rpm

(a) (b)

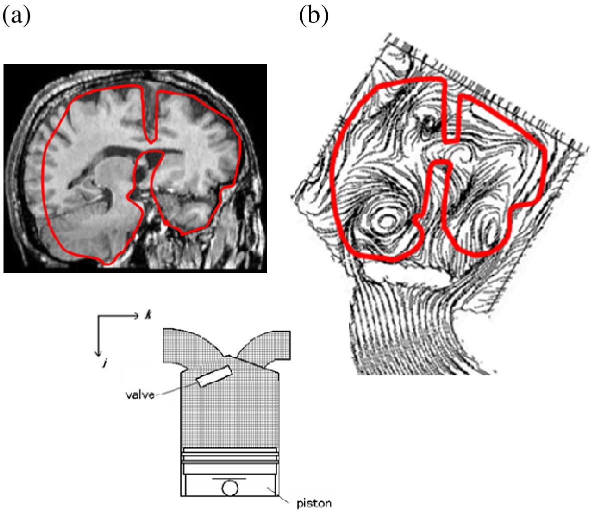


Fig.3 Comparison of brain MRI and engine flow (i-k cross section)
(a) Magnetic resonance imaging (MRI) of brain [5]
(b) Computational result at an engine speed of 1400 rpm

Figure 3a shows an image of the human brain obtained with magnetic resonance imaging (MRI) at a center cross section, while Fig.3b is the result of the corresponding computation performed with the Navier-Stokes equation for engine. Figure 3b is inclined in order to compare with the MRI image and engine flow field. The convexoconcave shapes inside the brain in Fig.3a are similar to those in Fig.3b.

Figure 4a shows an image of the human brain obtained with magnetic resonance imaging (MRI) at the cross section different from those of Figs. 2 and 3, while Fig.4b shows the vorticity surface computed in the engine. In this figure we can see two spheres representing the eyeballs and a cylinder representing the nose.

(a) (b)

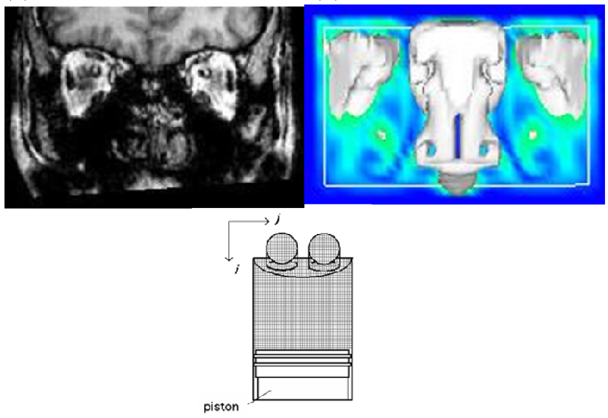


Fig.4 Comparison of brain MRI and vorticity in engine (i-j cross section)
(a) Magnetic resonance imaging (MRI) of brain [5]
(b) Computational result at an engine speed of 1400 rpm

Figure 5 shows the instantaneous stream lines computed at a very low engine speed of 1.4 r.p.m. A comparison with Fig.2 indicates that the flow pattern is independent of the engine speed.

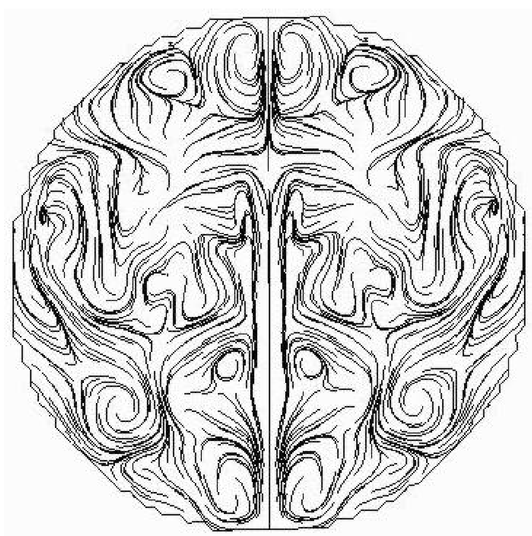


Fig.5 Instantaneous stream lines at a low engine speed of 1.4 r.p.m

Those computations were made at a crank angle of 72° after top dead center (ATDC) in the intake process, because at that point the cylinder volume of the piston engine considered here is about the same as that of the skull. (Fig.3)

Figure 6 shows the categorization of blood vessels in brain. In this figure, red line indicates external carotid artery, green line indicates middle cerebral artery, blue line indicates internal carotid artery, and yellow line indicates vertebral artery. We'll examine these four main blood vessels.

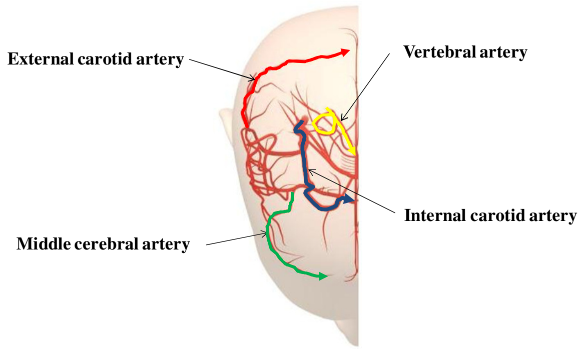


Fig.6 Categorization of blood vessels in brain [6]

Figure 7 shows the blood vessels in brain and the corresponding path lines in engine observed from three different directions. Each blood vessel can be also observed in the path lines for in engine at close positions, while the direction of flows are correct both for blood vessels and path lines in engine.

IV. CONCLUSION

In this paper, we can see the similarity between the convexoconcave forms inside the human brain and the flow structure of engine stream lines. In addition, the vorticity surface represents the eyeballs and nose that corresponds to those in the MRI imaging. Finally, we can conclude there is a similarity between blood vessels in human brain and engine path lines.

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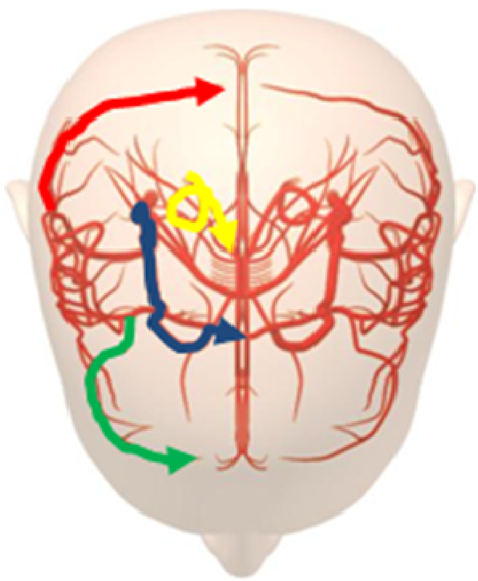

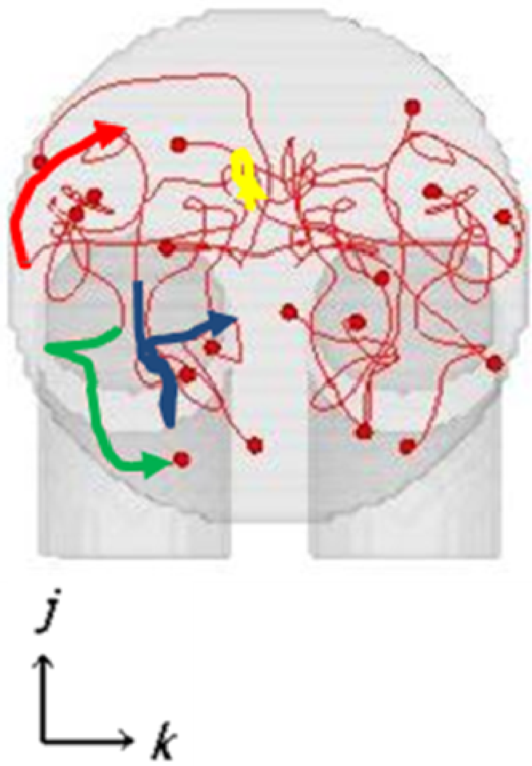

(a) Blood vessels in brain [6] (b) Computational result at an engine speed of 1.4r.p.m

Fig.7 Comparison of blood vessels in brain and engine path lines observed from the i direction

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