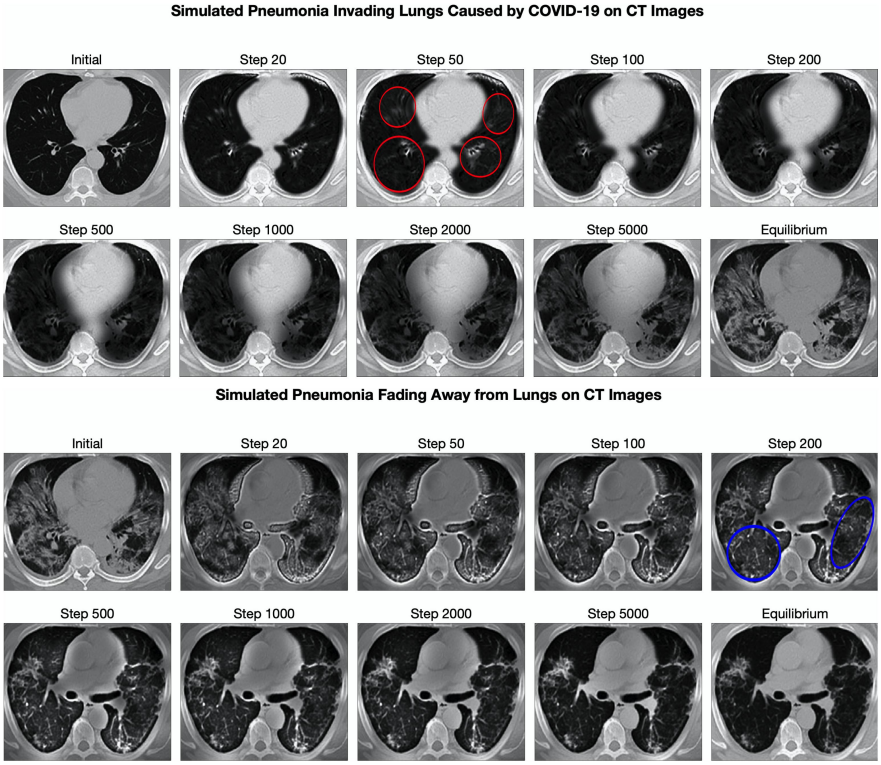
How Can the Data-driven Method Resolve the Underlying Dynamic process?

Part I. Understand the COVID-19 Pneumonia Invading and Fading Away Process

The pandemic starting from 2020 have influenced the entire world and taken away nearly 3 millions of lives. If a patient unluckily got the COVID-19, the most effective and efficient way to diagnose him/her is to carry out CT scans of his/her lungs to locate the damage parts caused by pneumonia. However, it is impossible to monitor the patient all the time using the CT scan images. Thus, the invading process is usually invisible for doctors and researchers, which bring up lots of difficulties to investigate further related therapies.

To solve this difficulty, we have developed a mathematical algorithm, which relies only on two CT scans, to simulate the pneumonia invading process caused by COVID-19. We compared with a series of CT scan images taken at different phases of a patient. This patient had severe pneumonia caused by COVID-19 but recovered after received a successful treatment. Our simulation clearly revealed the pneumonia invading process in the patient's lungs and the fading away process after the treatment. Moreover, simulation results identify several significant areas in which the patient's lungs are more vulnerable to the virus and other areas in which the lungs have better feedbacks to the treatment, compared to other lung areas. Those areas were perfectly consistent with the medical analysis based on the patient's real-time CT scan images. The consistency indicates the noteworthy of the method, which will provide potential evidences for the impact of coronavirus.



The COVID-19 pneumonia invading (upper panel) and fading away (lower panel) process from the data-driven simulations. Red circles indicate four significant areas in which the patient's lungs were more vulnerable to the pneumonia and blue circles indicate two significant areas in which the patient's lungs had more positive feedback to the treatment. (Image credit: Gao et al., 2021)

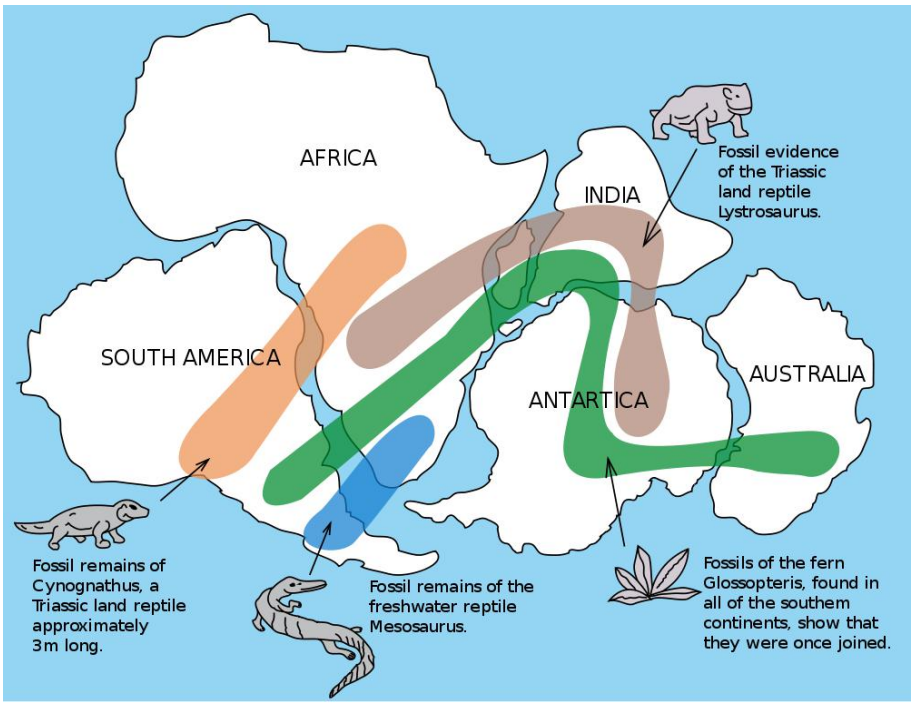
Besides, we also applied this method to simulate the human facial changes over time, in which the aging processes for different parts of a lady's face were automatically recovered with high resolution.

Facial aging transformation of a lady from the initial to the equilibrium status. (Image credit: Gao et al., 2021. Video)

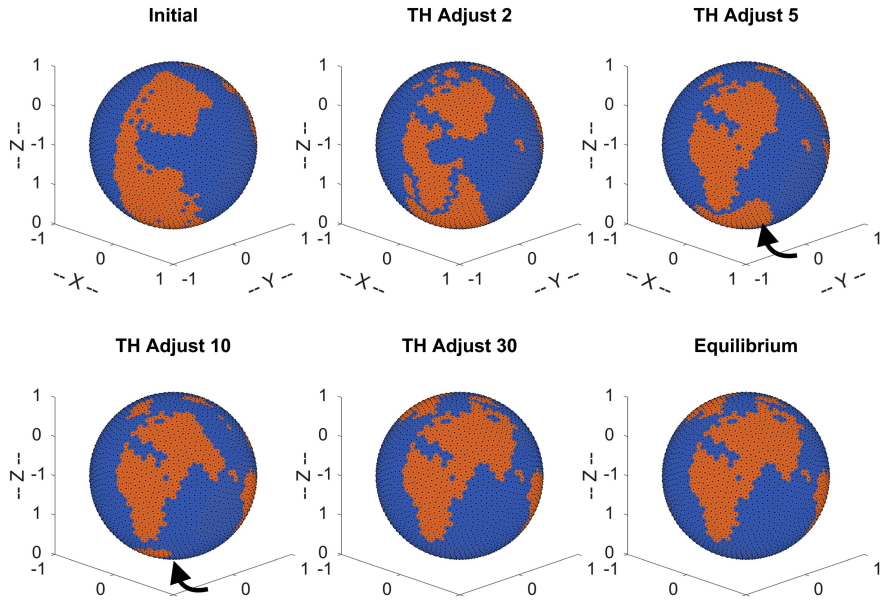
Part II. Solve the Puzzle of Continental Drift

It has always been mysterious how the current continents evolved and formed from the ancient single supercontinent (Pangaea) until German polar researcher Alfred Wegener proposed the famous continental drift hypothesis in the early 20th century. Although many geologists argued about his hypothesis at the beginning, more and more sound evidences such as continental structures, fossils and magnetic polarity of rocks have given them renewed interest in understanding how continents could move about on the planet's surface.

Our data-driven algorithm has been applied to simulate the possible evolution process of continents from Pangaea period. The underlying driven force for the continental drift in this case is determined by the equilibrium continental status of current planet. In order to describe the edges that divide the land ocean, we proposed a delicate thresholding scheme. The formation and deformation for different continents are clearly revealed in our simulation. For example, the 'drift' of Antarctic continent from Africa can be noticed in our case. The exciting simulation results present a quick and obvious way for geologists to establish more possible acknowledgments about how continents can drift from one status to another just based on the initial and equilibrium continental status. Combining with other technological advances, this data-driven method may provide a path to solve Wegener's puzzle of continental drift.



The theory of continental drift reconciled similar fossil plants and animals now found on widely separated continents. The southern part after Pangaea breaks (Gondwana) is shown here as an evidence of Wegener's puzzle. (Image credit: United States Geological Survey)



The continental drift process of the data-driven simulations. Black arrow indicates the formation of the Antarctic. (Image credit: Gao et al., 2021)

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