1 Robustness

Definition and Example

Robustness is a ubiquitous feature of biological systems and a fundamental organizing principle for dynamically evolving systems. In other words, it is the ability of dynamic self-adjustment in reaction to external and internal perturbations [1].

The immune system maintains its robustness for the organism by relying on its three major functions of immune defense, immune surveillance, and immune self-stabilization [2]. It plays an important role in maintaining the homeostasis of the body's internal environment by detecting and eliminating foreign pathogens, preventing infections, and monitoring abnormal diseased cells in the body. When a pathogenic attack occurs, the collective response called immunity occurs. Take the covid-19 virus as an example, one of the most obvious symptoms is the raise of body temperature. This is because increased body temperature can directly slow down the proliferation of viruses and bacteria, making them more susceptible to attack by the immune system. This is how human body adjusts itself to provide a better condition for defending pathogenic. Quick settlement of problems offer a stable functioning environment for the organism in the long run.

Importance

Robustness is important for understanding the principles of life and has great medical implications. This concept can be a bridge between the fundamental principles of life, medical practice, engineering, physics and chemistry. The implications will be enormous. Complex biological systems must be able to resist environmental and genetic perturbations in order to evolve and higher rate of survival [3]. Evolution usually selects for features that may enhance the robustness of an organism. Thus, robustness is ubiquitous in organisms that have evolved. However, robust systems face vulnerability and performance setbacks as an inherent trade-off. Determining the underlying architecture of robust systems and the associated trade-offs is critical for understanding their failures and countermeasures, especially for diseases and for designing effective therapies.

2 Fragility

Definition and Example

Biological fragility is said to be a by product of robustness, indicating the potential failure of biological systems defending fluctuations of internal and external conditions, which might lead the whole system to breakdown.

For instance, epilepsy is a phenomenon proving by the fragility of neural network in brain, which

is a typical biological system. A common reason of this abnormal activity is the specific structural changes to the most fragile nodes or neurons in the network, as referred as a internal perturbation. Epileptic cortex is always unstable and once the most fragile node is disturbed, the network would lose stablity and cause seizures [4].

Suggestions

Plenty of systems showed high fragility along with the increase of complexity [5]. During the process of evolution, a biological system tend to transform from a simple but versatile structure to multiple complex sub-systems with distinctive functions. For complex systems abundant information is transformed amongst, which intensifies the fragility. To avoid the possible breakdown of any biological systems, a proper understanding of the system's behavior and failure modes, which is any effective countermeasure requires. Moreover, available alternative mechanisms or modules that shares overlapping functions can reduce the risk of fragility [3]. Once a cell or component is perturbed and behaves inappropriately, it can be removed and substituted. Another way to prevent fragility can be considered from another aspect. Instead of modifying or optimizing the system itself, the 'enemy' can be considered as another system and by finding and utilizing the fragility of 'enemy' system, the fragility is prevented naturally.

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