An engineering theory puts a new spin on what we can expect regarding…

The Reliability of Life Extension

Have you heard the story of the 5000-year-old human? No, not the one about the ancient Tyrolean Iceman found frozen on the border of Italy and Austria, but a new one, a story that may land us safely in the distant future—healthy and with our consciousness intact—provided that we are anything like machines.[1]

According to the application of an engineering theory, described in the September 2004 issue of *IEEE Spectrum,*[2] the ceiling for maximum lifespan could be raised to the staggering height of 5000 years. In their article, Leonid Gavrilov and Natalia Gavrilova, two University of Chicago biologists, hypothesize that the aging process can be understood and ultimately controlled through what is called engineering reliability analysis. This strategy had grown out of attempts in the 1950s to describe the aging and failure of complex electrical and electronic equipment. It is based on the adoption of concepts, methods, and models from what is now known as reliability theory, which has continuously improved over the last several decades.[3]

Succinctly put, reliability theory predicts how a system, given its specific architecture and our knowledge about the reliability of its constituent parts, will fail over time.[4] Gavrilov and Gavrilova's insight is that reliability theory applies equally to understanding aging in living organisms, including ourselves—how we age and how we die. In this respect, we are not so different from the machines we build, because we too have redundant components and systems, many of which are defective right from the start, they contend.

Consequently, reliability theory enables us to think of aging as the increased risk of failure of the machine that constitutes our biological system. Hence, aging is "a direct consequence or tradeoff of systems-redundancy exhaustion." In other words, aging is the increased likelihood that we will die tomorrow rather than today, because our risk of failure increases as time goes by. If the risk of failure does not increase as time passes, there is no aging.

Remarkably, note the researchers, the patterns of human aging are similar in many ways to how technical devices age and fail. In both cases, the rate at which failure occurs follows a U-shaped curve in which mortality rates are greatest at the beginning and end, with a slowdown in the middle. It is this middle portion, straddled by the stages of infant mortality and age-related decline and mortality, that is the researchers' primary concern. They call it the "normal working period" because the rate of failure is very low during this period—the systems are working nearly optimally. However, in humans, at least, this period is very short, beginning at age 5 and lasting just 10 to 15 years. "If only we could maintain our body functions as they are at age 10," argue Gavrilov and Gavrilova, "we could expect to live about 5000 years on average."[2]

As others have pointed out, when humans pass the age of 90, the risk of death diminishes and approaches a plateau. Machines share these characteristics with humans as they approach very old age. To clarify this point, Gavrilov and Gavrilova point out that the risk of death at 110 is not much different than the risk at 102, even though your chances of seeing your next birthday are not very good. Your risk has leveled off. Surprisingly, this is also true for such manmade stuff as metals, industrial relays, and the thermal insulation of motors. Biologists have attempted to explain this phenomenon by evolutionary and reproductive theory, but to little avail. Perhaps reliability theory can provide some better answers.

As there is no upper limit to how long machines can last, perhaps there is no fixed upper limit to human longevity, the researchers suggest. Surely they're joking, because this contradicts what we believe we know about fixed maximal human lifespan and the limits of longevity. Yet Gavrilov and Gavrilova seriously maintain that reliability theory applies to biological aging because it is possible to think of humans in terms of their redundant parts—parts that do not, by themselves, age.

In their attempt to make the model fit, Gavrilov and Gavrilova challenge the assumption that humans start life without built-in errors. Instead, as reliability theory implies, they believe we actually begin life with a great many defective parts. This is a crucial point of their theory. By accepting the idea that we're born with a great deal of damage, we make it reasonable to conclude that even very small improvements in the early stages of life matter a great deal. This means that increasing the quantity of life's initial functional elements could result in big yields for human life, as it does for the life of manmade systems. Reliability theory predicts a precipitous drop in mortality, a great increase in longevity, and perhaps 5000-year lifespans. A happy thought!

References

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