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Chapter IV

Concept and Definition of Complexity

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Abstract

The term complexity is used informally both as a quality and as a quantity. As a quality, complexity has something to do with our ability to understand a system or object—we understand simple systems, but not complex ones. On another level, complexity is used as a quantity when we talk about something being more complicated than another. In this chapter, we explore the formalisation of both meanings of complexity, which happened during the latter half of the twentieth century.

Introduction: Is Complexity a Quality or a Quantity?

The term *complexity* has two distinct usages, which may be categorised simply as either a quality or a quantity. We often speak of complex systems as being a particular class of systems that are difficult to study using traditional analytic techniques. We have in mind that biological organisms and ecosystems are *complex*, yet systems like a pendulum, or a lever are simple. Complexity as a *quality* is therefore what makes the systems complex.

However, we may also speak of complexity as a quantity—with statements like a human being being more complex than a nematode worm, for example. Under such usage, complex and simple systems form a continuum, characterised by the chosen complexity measure.

Edmonds (1999) performed a comprehensive survey of complexity measures as part of his PhD thesis, however it has not been updated to include measures proposed since that time. However, it remains the most comprehensive resource of complexity measures available to date.

The aim of this chapter is not to provide a catalogue of complexity measures, but rather to select key measures and show how they interrelate with each other within an overarching information theoretic framework.

Complexity as a Quantity

We have an intuitive notion of complexity as a quantity; we often speak of something being more or less complex than something else. However, capturing what we mean by complexity in a formal way has proved far more difficult, than other more familiar quantities we use, such as length, area, and mass.

In these more conventional cases, the quantities in question prove to be decomposable in a linear way (i.e., a 5 cm length can be broken into 5 equal parts 1 cm long) and they can also be directly compared—a mass can be compared with a standard mass by comparing the weights of the two objects on a balance.

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