OLM 2.1. The state of the lion, and forecasting its behaviour

When applying a theory to a certain specific object the problem of providing more reliable predictions and reducing the inherent contingencies is always pertinent. What can we do if the state of the system studied cannot be specified at a level necessary for making deterministic predictions? The fable of the hungry lion that follows is an example to this problem.

What happens to a system in the future (i.e., how its state changes) is determined by two different groups of factors. Let us take the hunting lion as our example. The first type of relevant factors is the internal state of the system (is the lion hungry?), the second one is that of the influences coming from the external world (does it encounter appropriate prey items like gazelles to hunt down?). For simple systems the state changes can be accurately predicted if the actual state and the external impacts are known in sufficient detail. Such simple system state changes include the movements of planets, for example, not a hunting lion. A series of such predictable changes amounts to forecasts into the deterministic future of the system – for example, the precise time of future lunar eclipses can be accurately calculated. Detailed knowledge of the initial state and the external effects is indispensable, of course – so much so that the theory of dynamical system speaks of *state specification* only if the system and the relevant external effects are described in sufficient detail for making a deterministic prediction possible. We cannot say *a priori* what depth of system specification is sufficient for making accurate predictions, but we have learned from experience that predicting the future movement of a planet requires knowledge of its initial position and speed, for example. Then it turned out that for a very accurate prediction of the trajectory of an asteroid one needs to know the parameters of its rotation as well (Yarkovsky effect). No one would have foreseen its relevance earlier. We have no chance whatsoever to predict the behaviour of a lion deterministically. Since the elementary activities of a lion (like its venturing into hunting) are stochastic, the sequence of its activities is a *stochastic process*. We cannot predict the future states of the lion – we can specify only the probability distribution of its possible future states. Ch3.2 and TBox 3.2 within it, Ch4.2 and Ch11.1 give examples of the methods of stochastic forecasting.

Could we make a deterministic prediction if we knew all the physiological parameters and all the characteristics of the cerebral functions of the animal? We may doubt that. The sensible approach in this case is a probabilistic description: if the lion has not eaten anything for the last two days and there is a herd of springboks grazing nearby it makes hunting very likely. The stochastic state concept is less stringent than the deterministic one: the state of the system needs to be specified at a level enabling probabilistic predictions of the system's behaviour (Markov process, TBox 4.1). Moreover, we have no way of *a priori* knowing the level of detail required for an appropriate state specification: we might need to know other details of the lion's physical state, e.g., its health, as well. But look out: including hunger or health status among the state descriptors means we have to follow the stochastic dynamics of these variables, too. The number of variables should be kept at its necessary minimum, just as we would consider the rotation of the asteroid only if it is absolutely indispensable. Interactions also need to be considered: hunting makes the lion tired, starvation makes it weak, and both influence its behaviour.

We cannot be over-cautious regarding the generality of our predictions, however. After having invested a lot of work we may come up with sufficiently reliable predictions for the daily activities of the lions we observed, but it might well be that for some reason that we were not aware of they are lonely hunters, in which case our predictions are useless for group-hunting individuals of the same species. Our inevitable ignorance of many unknown factors possibly influencing the behaviour of the system we study will impair our predictions.