Chapter 1

Free Will Systems

fernando.cacciola@gmail.com

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*** WORK IN PROGRESS ***

Overview of Dynamic Systems

Consider a **dynamic system** composed of a *finite* number of **objects** such that any object can be in any single one of a *finite* number of **states**.

An *object* is any part of reality (actual or imaginary, concrete or abstract) that is somehow *distinguished* from everything else. Intuitive examples include *physical* macroscopic objects such as a rock, a planet or a galaxy; *metaphysical* objects such as persons or pets; and *abstract* objects such as numbers, words or drawings.

In physics, for instance, an object is usually referred to as a (physical) "system" and the distinction is drawn when it is considered to be possible to

isolate it from the rest of the universe: a rock, for example, is an object (or a physical system) for it can be physically separated from the surroundings such that certain properties about it remain the same when placed under many different environments, that is, *when the distinction persist*. A subatomic particle, such as an electron, is also a physical object (or system) for it also can be persistently distinguished from other electrons and the rest of the atom on several different scenarios.

An object is a distinction, but distinctions are usually *drawn* rather than inherent. For example, a rock is really just a continuously mutating collection of molecules which just happen to be of a different type from the type of molecules usually found in the environment right around the rock, such as gas, water or dirt. That difference in molecule types gives the collection of molecules--as a whole--a certain set of characteristics from which the distinction can easily be drawn (mostly cohesion to form a solid body and surface texture to look a certain way when light reflects on it). The *process* of drawing the distinction dynamically determines what is the rock, and it involves the participation of an *external agent* which is drawing the distinction (whether is a person looking at it, or a mechanical device separating it from other objects).

Let us then define a **proper object** as any object that inherently distinguishes all by itself without the participation of any external agent explicitly drawing the distinction. The simplest examples of proper objects can be found in the abstract world. For example, a two-dimensional circle of radius 'R' centered on the origin of a certain cartesian coordinate system is a distinct proper object all by itself and there is no need to explicitly *make* a distinction in order for the circle to be itself. So is a number, or a word.

Actual *proper objects* in the real world are much more difficult to correctly identify. All our models of the physical universe, from planets to rivers to atoms to quarks, are based on carefully but artificially drawn distinctions based on observations and experiments. However, the concept and hypothetical reality of actual proper objects is central to the problem of free will, so this will be refined and qualified through the rest of the this work.

State is the collection of properties of, about, or on an object. Simple examples for *physical* objects include *temperature, acceleration, color, or shape.* For *metaphysical* objects, examples include *emotion, knowledge or motivation*. For *abstract* object, could be "*a list of numbers that represent something that is encapsulated in the abstraction*" or *"the style used on a piece of art"*.

In general, the word "state" is used to refer to *all* of the properties of an object, *everything* that is to know, or can be known, about it. Thus, strictly

speaking, "position" or "knowledge of history", are partial or sub states. However, in many contexts, only a part of the state, such as "position" alone, can be referred to as "the" state, even though is strictly just partial.

For any given object, some properties are independent of anything external to the object, for example, the radius of a circle is independent of anything but that circle. Other properties are only the result of interaction between the *referent* object (whose property is considered) and a *reference* object(s) (the things that interacts with the referent). For example, the weight of a physical object depends on a property of the object itself, the rest mass, but also on the Earth whose gravitational field gives weight to the object.

Independent properties, such as the "rest mass" of a physical object (when considering the simplified models of the so-called "classical mechanics"), are the same regardless of the external conditions of the object (the rest mass is the same here or Mars), unlike dependent properties, such as the weight of an object, which is different here than in Mars.

Let us define :

- An **Internal Property** of an object is any property that is independent of anything outside the object (such as the number of words on a book).

- An **External Property** of an object is any property that derives from the interaction between the object and its environment (such as the potential energy that a physical object possesses by being in a certain position within a certain "field", like gravity).

Now let us say that an object then ***possesses*** **an internal state** (the set of all internal properties) and ***displays*** **an external state** (the set of all external properties)

Notice that virtual objects also have properties (hence both internal and external state). An obvious example could be the "remaining strength" of a video-game avatar. A less obvious but still correct example could be "the (average) food-serving speed of a McDonalds store". Although the serving is the result of physically concrete actions and the speed in question can be properly traced back to concrete, not virtual, entities; the "average food serving speed" property does not refer to any concrete physical entity. Is not the "order-taking" speed of Bob, or the "burger-cooking" speed of Alice that is being considered, but that of the virtual object that is the store as a whole. It does not matter which concrete actual persons work on the store (Bob, Alice or both), the store still has a well defined, perfectly observable, average food-serving speed. The existence and observability of state on virtual systems is central to

this work on free-will, and will be elaborated in the chapter on "role-based free-will systems".

In order for *us* to make any informational use of the properties (internal or external) of an object, they need to be given a representation. For example, in the field of physics, the representation comes out of *quantification* : that is, a process known as *measurement* assigns a numeric value--a quantity--to the property. Having properties represented by numbers allows us not only to be as exact and precise as possible but to operate mathematically with them and relate different properties of an object (such as its position and speed), or among objects (such as the gravitational force between a pair of objects). Even if a measurement is performed by subjectively mapping the property to a variable on an arbitrary scale, such as when a doctor asks a patient to rank their own pain on a scale from 1 to 5, once a property has been formally quantified (represented numerically) it can be logically and mathematically used (for example, the doctor can formally record the reported pain rank, then other health care professionals can look at it and infer what to do).

Outside the mathematically oriented world of Science, properties might not be quantified but they are still represented, using *qualification*. For example, a snack could be qualified as tasty or dull, and that adjective--that quality--becomes the representation of that property of the given snack.

Let us define :

- A **Variable** is any representation, whether quantity or quality, of an internal or external property of an object.

- An **Observable** is any property of an object for which a *process* mapping such property to a *variable* exists (even if only in theory).

- An **Observation** is the process mapping an observable to a variable.

- An **Observer** is any agent carrying out an observation.

In this work, the term *property*--whether internal or external--refers to the intrinsic characteristic of an object on and by itself, regardless of anything *we* can tell about it. A *variable,* on the other hand, is a representation of a property that we create within our cognitive world. This distinction is important in developing certain concepts that are fundamental to the problem of free-will. For example, in physics, we describe the position of an object in terms of variables, but the object is at a certain "place" (whatever and whenever that is so) regardless of our attribution of its position. Even if in reality the there is no such thing as a "position property", there is, necessarily, *some* property or

properties *from* which we attribute the variable "position".

Specially within Science, variables are usually governed by mathematical equations (or other *formal methods*) which predict their values in different conditions, such as the passage of time or as the result of interaction. Calculations might yield exact values, intervals or probabilities, but in all cases, what is expressed by the equations, or the so-called "Laws of Science", is the *expected* value of the variables of an object according to any particular theory or model.

- A **Prediction**, or **Formal Variable**, is a variable given by a mathematical or logical expression.

- A **Measurement,** or **Empirical Variable,** is the variable obtained by empirical observation.

While a measurement is a form observation by which we *empirically* obtain a variable representing a property, a mathematical or logical expression is also considered an observation, one by which we formally calculate the expected variable for a property. That is, an observable is any property for which we can obtain a variable as a representation of it, whereas by measurement or prediction.

This distinction between properties, variables, observables, predictions and measurements is important for the development of the concepts in this work, but have in mind that these terms are sometimes used interchangeably on certain contexts.

A measurement is then an empirical variable that is effectively obtained by an empirical observation process, as opposed to a formal variable that is, for instance, just calculated from an equation. This distinction is often implied, or omitted, but is critical since predictions are dependent on our own theories and models of reality whereas measurements are dependent on reality itself. It is the degree of correlation between formal and empirical variables (that is, predictions and measurements) which determines the value of a given scientific theory.

Notice that an observable requires that a suitable representation exists (usually a properly defined quantity), but does not demand the actual existence of empirical observation, only that empirical observation is possible. For example, each and every planet on the Universe is considered to be an observable even if we had never yet actually observed each and every planet. On the other hand, there could be proposed properties of an object that are not

(yet at least) observables. A classic example are most of the consciousness-related properties of human beings. A (proposed) property of an object that is not (yet at least) quantifiable, or at least qualifiable, is not an observable for there isn't even a proper process for obtaining a representation of it (a variable, even if only formal)

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CONTINUE WITH: ontological difference between properties as features of reality and variables (and observable) as features of our cognitive models of reality

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- A **Dynamic** object is an object whose state changes, partially or completely.

- A **Stationary** object is an object whose state (the set of all internal and external properties) is, partially or completely, fixed.

All physical objects are dynamic as they are consistently found to change state (by changing position, composition, shape, etc...) from time to time. A metaphysical object, such as a person, is also dynamic as it is also consistently found to change properties such as emotions or knowledge.

When considering only a sub-state (just some properties but not all), such as "chemical composition", or external properties, such as the position with respect to a reference origin, an object might be *partially stationary* relative to that sub-state or external property. Abstract objects might easily be *completely stationary*, such as "the English alphabet" that has a fixed number and content of letters.

- An **Event** is any change in any *variable,* formal or empirical, representing a change in an object property (internal or external).

Recall that a variable is the representation of a property, hence, an event is the representation of a change in that property. That is, an event is *not defined* here as a change of property but as a change of variable. Any change in the state of an object that is not formally expressed or observed is not an event.

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CONTINUE WITH: review

The **Intrinsic Clock** of a dynamic object is the ordering of its state changes.

Fundamental to this work on free-will is the recognition that any reason for *expecting* any calculated variables given by a particular theory to match measurements, is, ultimately, a metaphysical presupposition. For example, using the equations from classical mechanics we can expect a moving object, for which we know its initial position, mass and speed (what physicist call the *configuration phase space* of the object), that is subject only to certain known forces, to end up at a certain position after a period of time. And as far as we can tell, any measurement had always matched the expected position (within the limits of the measurement precision). However, that the object will-- in the future--effectively be found at the expected position can only be demanded by assuming a certain metaphysical worldview, such as determinism. Distinguishing the *utility* of scientific theories in robustly predicting dynamic variables from the variety of metaphysical worldviews that may account for the success of such predictions, allows us to consider different and competing worldviews. This work, for example, presents a worldview based on free will systems.

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