Philosophy & Technology (2023) 36:34
https://doi.org/10.1007/s13347-023-00633-8

Between Fiction, Reality, and Ideality: Virtual Objects as Computationally Grounded Intentional Objects

Bartłomiej Skowron[1] · **Paweł Stacewicz**[1]

Accepted: 7 April 2023 / Published online: 1 May 2023

Abstract
Virtual objects, such as online shops, the elements that go to make up virtual life in computer games, virtual maps, e-books, avatars, cryptocurrencies, chatbots, holograms, etc., are a phenomenon we now encounter at every turn: they have become a part of our life and our world. Philosophers—and ontologists in particular—have sought to answer the question of what, exactly, they are. They fall into two camps: some, pointing to the chimerical character of virtuality, hold that virtual objects are like dreams, illusions and fictions, while others, citing the real impact of virtuality on our world, take them to be real—an actual part of the real world, just like other real objects. In this article, we defend the thesis that both sides are wrong. Using Roman Ingarden's phenomenological ontology, we advocate a position according to which a virtual object is a computationally grounded intentional object that has its existential foundation in computational processes, which are compliant with a certain model of computation. We point out that virtuality is framed by some kind of ideal mathematical objects: i.e., mathematical models of computation, which in turn fall, each of them, under their respective ideas. We also refer to the idea of natural computation, which in conjunction with the ontological analysis carried out leads to the thesis that an object can be more or less virtual.

Keywords Virtual object · Real vs. virtual · Intentional object · Roman Ingarden · Model of computation · Computational feature · Digitality · Natural computation · Ideas

✉ Bartłomiej Skowron
bartlomiej.skowron@pw.edu.pl

Paweł Stacewicz
pawel.stacewicz@pw.edu.pl

[1] Faculty of Administration and Social Sciences, Warsaw University of Technology, Pl. Politechniki 1, 00-661 Warsaw, Poland

1 Introduction

Virtual objects are everywhere. Each and every day we find ourselves surrounded by them wherever we turn, and they alter our habits and influence our social relationships. But what are they? For some thinkers, they are a form of "consensual hallucination"[1] or fiction. For others, meanwhile, such as Chalmers (2017), they are real. In the present article, we shall ourselves defend the view that they are neither real nor fictional. Our thesis will be that they straddle the boundary between reality and fictionality. Both their reality and their fictionality are gradational (as distinct from either-or) characteristics. Moreover, this straddling itself rests on a supporting structure whose own character is best understood as ideal: namely, that furnished by some specific model of computation which is predetermined by the relevant idea.

Among the many different meanings of the term "virtual object", we prefer to highlight the one familiar from the IT sector, according to which a virtual object is a specific product of computer science (a computational artifact) in some respects resembling some other different type of object (i.e., one that is natural, or that is man-made without any conscious use of computational techniques). For example, an online shop is called 'virtual' because its appearance and operation are controlled by computational procedures, while its function (selling goods) is the same as that of a traditional shop. Moreover, in everyday discourse, the IT-based meaning of the term 'virtual' is certainly the predominant one: for a person living in a society in which IT has come to play a significant role, 'virtual' counts as practically synonymous with 'computer-related', 'computer produced', or simply 'digital'.

Virtual objects, just like other cultural artifacts, are without doubt created by human beings. Their characteristics are given to them by their creators. More precisely, these attributes depend entirely on the acts of consciousness that bring them to life. Intending it to be, at this stage, only an initial approximation, we may call such objects 'intentional'. With this in mind, and focusing on computation-related contexts, we propose the following rough explication of what the term means: it is *an object created by human consciousness (i.e. an intentional one), maintained and ideally conditioned in its existence by computational procedures that themselves have a theoretical basis in various types of algorithm and, underlying this, various models of computation that fall, each of them, under their respective ideas.* In short, it is a *computationally grounded, ideally pre-conditioned, intentional object*. We shall commence our analysis, then, by adopting this as a working description of what it is we are dealing with.

Since this characterization is essentially embedded in an IT-determined—which means, in many cases, computer-based—context, the underlying objects will be referred to as *computational virtual objects* (for which we shall hereon use the abbreviation CVO), in order not to exclude the possible existence of other types of virtual object. After all, we might well wish to regard physical models of various fragments of reality as furnishing other possibilities here, these also being artifacts: e.g., a

[1] This is what William Gibson said, quoted from (Chalmers 2017, p. 309).

static model of a building, or a moving mechanical model of a planetary system. In this paper, though, we shall just focus on virtual objects that are *computational*.

It is also worth noting that one member of the CVO category consists of virtual reality systems, these being highly complex virtual objects that interact with people in a very realistic and sensuously vivid way (i.e., what is sometimes referred to as their 'immersive character') (Chalmers, 2017; Heim, 1993; Steuer, 1992). However, the present paper does not only deal with objects of this kind: it rather aims to address a significantly broader category. The same applies to simulations and interactions: virtual objects can, to be sure, be conceived as simulations or interactive objects, but in our analysis neither the idea of a simulation nor that of an interaction will count in themselves as essential aspects of their description.

As can be seen, the word 'object' is being used here in the widest possible sense.[2] It is understood as something that need not actually exist, i.e., it can be merely possible or conceivable, and as including both objects in the strict sense, i.e., as bearers of properties, and also processes, relations, events and states of affairs (which are treated as non-objects in the narrow sense of the term *object*), and as allowing for both objects that persist in time and ones that are timeless—including, even, domains of being or non-existent objects. Finally, it may also be an idea, or something else yet to be specified. This broad notion of objectuality includes virtual objects of quite different forms, such as particular virtual bearers of properties, virtual relationships between particular virtual objects, virtual states of affairs, processes, words, systems, as well as virtual qualities.

The ontology of the virtual object raises many questions (cf. Chalmers, 2017; Laas, 2015; Skowron, 2020; Smart, 2022; Turner, 2022). Hence, it is necessary, we think, to start from scratch—that is, to assume nothing whatsoever about the form, matter or mode of existence of virtuality. So, for example, as regards such form-related questions as whether virtual beings are objects in a narrower sense, or processes, or things, or states of things, or words—this is not something to be resolved prior to other matters. Such a starting point for analysis means, of course, beginning with nothing already there in one's hands, but this surely purifies the field of reflection and allows for an ontologically unbiased approach. At any rate *that*, we think, is the spirit in which the phenomenologists (Husserl, Ingarden) were working when they sought to explore the relationship between reality and fictionality. Our own aspiration is thus also to try to make as good use as possible of the findings of these thinkers—in particular Ingarden—while pursuing our own analysis of the nature of virtuality.

Virtual objects (including virtual reality, mixed reality, computer holograms and augmented reality) permeate the life of contemporary humanity through and through. As has already been mentioned, they also pose many problems for ontologists. We would like to know if they are real in the way that stones and houses are, or fictional like dreams, simulacra, illusions, or the characters in a novel. Perhaps they are a new kind of object never seen by ontologists before? It is hardly surprising,

[2] The ontology of the virtual object presented here draws on that of Roman Ingarden. Nevertheless, the characterization of the concept of objectuality given here does not correspond to his formulation. For Ingarden's own account, see Piwowarczyk (2020).

then, that some traditional ontologists seem keen to avoid this specific topic, as there are no simple readily available tools to help us make sense of it. Our view is that existential monism, a position in metaphysics frequently embraced by contemporary philosophers according to which an object either exists as real, or quite simply does not exist at all, and dualist metaphysics, in which it is held that we are all the time dealing with just two modes of being, are both too impoverished to accommodate all aspects of virtual objects. Hence, there is a need for a pluralistic metaphysics, of a kind broad enough to make visible the many and varied aspects of virtual objects. Roman Ingarden, in his book *Controversy over the Existence of the World* (first published in 1947/1948), put forward a metaphysics that presents and explores many different modes of being, and as such it seems well-suited to serve as a framework for the present analysis.

In the second part of this article, which sets out Ingarden's overall conception, we present the basic tools of his ontology: in particular the so-called existential moments pertaining to notions of existential autonomy and heteronomy, (non)self-sufficiency, ontological originality and derivativeness, (non)activeness, fissuration, and existential (in)dependence. Thanks to these concepts, we are able to introduce multiple different modes of being (synonymously referred to as ways or modes of existence), including *ideal being*, *real being* and *intentional being*. Thus, we start with metaphysical pluralism, the central posit of which is that there are many ways to exist. We then define the notion of a 'virtual object' in general terms as an intentional object, and, by drawing attention to its involvement in a process of becoming existentially autonomous (more crudely, of 'becoming real', as described previously by (Skowron, 2020), explain in what sense the virtual object straddles the boundary between reality and fiction (where fictionality is itself construed as falling within the domain of intentionality). As part and parcel of this, we also discuss the existential gradationality of virtual objects, referring once again to the aforementioned process of existential autonomization.

In the third part of the paper, we focus on the thesis that CVOs have their existential foundation in computational processes, which are themselves realizations of certain models of computation, that in turn fall under the relevant ideas. Thus, we point out that virtuality is framed by some kind of ideal mathematical objects: i.e., mathematical models of computation and their ideas. In the fourth part of the article, we specify what this ideal framework is. We distinguish several types of CVO, based on the type of model of computation that is realized. In particular, we analyze the distinction between the Turing or digital model, formally captured using the universal Turing machine, and non-Turing or non-digital ones, based on various types of hypercomputation. Then, recalling the strategies for defining non-digital models by modifying such features of the classical model as discreteness, finiteness or determinism, we introduce different types of virtual objects, taking into account both those that actually occur and those that are merely possible: namely, digital, analog or quantum CVOs. While the second section of the article explores how CVOs become real through a process of acquiring existential autonomy (how they ascend what amounts to a highly differentiated 'ladder of being', passing from intentionality to reality—the rungs of the ladder being, from the bottom upwards, *fiction*, *reality*, *ideality* and, right at the top, *absoluteness*), in the fifth section we draw attention to a movement in the opposite direction, from reality to intentionality. This involves referring to the procedures, still regarded as exotic but taken seriously in theoretical computer science, associated with natural computations, such as biological computations using DNA structures. At the same time, we claim that the more this involves references to nature, the more the corresponding CVOs will become non-virtual. In this manner, we aim to capture another way in which virtuality's essential gradationality is disclosed. The sixth part of the article then deals with the stratified character of the intensity of existence of CVOs. Finally, in our conclusions, we attempt an overall synopsis of our findings.

2 Intentional Objects

2.1 Existential Moments and Modes of Existence

Our goal here is to elaborate more fully the theses of the intentionality and existential gradationality of CVOs,[3] assisted by the phenomenological ontology of Ingarden. Hence, we shall begin by briefly outlining the basic ideas and central elements of the latter's highly developed framework.

Even prior to this, however, it seems appropriate to first spell out why Ingarden's ontology,[4] more than any other, seems to lend itself especially well to serving as a framework for analyzing virtuality. Virtual objects are typically defined as objects that are interactive, immersive, and/or computer-generated, and/or ones that simulate reality (cf. Chalmers, 2017, p. 312). They are not real objects; rather, they are closer to fictional ones.[5] As such, we tend to treat them as fictions themselves. Yet even if they are not real, they still enter—as fictions—into real causal relationships (Chalmers, 2017; Smart, 2022). Probably nobody would deny that such objects are exerting an influence right now upon the real world—and, indeed, are changing it at a dizzying pace. Amidst all this confusion, a natural question arises: are virtual objects fictional (and dependent somehow on human consciousness), or real—or, indeed, somehow located between the fictional and the real? To answer this question, it is not enough to simply declare them one or the other, real or fictional, as this in itself contributes nothing to the discussion. We need to carefully analyze the difference between reality and fiction: how they are dependent on human beings, and how not. In order to do this, we must first have at our disposal an adequately rich ontology.

---

[3] It is worth mentioning that Olivier Laas (2015) begins his study of virtuality from a fundamentally different perspective from ours: i.e. he denies the need to distinguish virtuality as a mode of existence, adopting an ontological nominalist position, while arriving at very similar intuitions to ours in that he attributes gradualism to virtuality. We thank an anonymous reviewer for pointing out the similarities between Laas's intuitions and ours.

[4] Our view of why it is necessary to invoke Ingarden's ontology here is in line with the arguments given in (Skowron, 2020).

[5] A brief overview of contemporary fictionalism is presented by Chalmers (2017, p. 315–317). It is not necessary to elaborate all such positions in detail here.

The ontology which states that there is one kind of being, that of real beings, and that everything not real simply does not exist (or is fictional), is an ontology that fails to explain anything or push things forward, in that its assumption of metaphysical and existential monism inadvertently prescribes a single solution to the problem before the latter has even be subjected to discussion. The significance of ideal entities is often implicitly registered, but only to be superficially glossed over. This is something we aim to avoid on the approach adopted here: by contrast, Ingarden's ontology must count as one of the richest ontologies ever created, it being neither specifically idealist, realist, fictionalist, nor structuralist: it allows for all of these at the same time, while also leaving room for a great deal more. "Like it or not", as one might say, *existence is complex*.

Ingarden meticulously analyzed the unobvious connections between fiction and reality, and between idealism and absoluteness. He presented dozens of ways in which one object could depend on another, simultaneously claiming that he himself had by no means exhausted all of the possibilities. His ontology is thus an open system, and can be further enlarged—a feature that also counts as one of its advantages. Nevertheless, as we shall see in due course, such as an ontology also possesses certain drawbacks.

Every being, in Ingarden's view, can be analyzed with the help of three components that permeate it: form, matter and mode of existence (or mode of being). Matter is the first thing to be noted, this being everything qualitative about a given being: e.g., the color of some object. Its form, meanwhile, is what is non-qualitative, and corresponds to its being a process, thing or idea. For Ingarden, it is in virtue of this that processes, things and ideas differ from one another. For our present purposes, though, the most important component of being will be its mode of existence—its 'way' or 'manner' of existence, if one prefers. This cannot be observed at all, and is not something we notice as we might some object's matter: when we look at a real object, we do not see its mode of existence as, say, we see its color. Here, already, we are confronted with our first obstacle to distinguishing this component of being. However, let us not become discouraged too quickly: when we consider any object, we may ask what the source of its existence is: what is the raison d'être of its existence? It seems, at first glance, that the reason for the existence of an autonomous car is different from the reason for the existence of the Hilbert cube (i.e., a topological space that is an infinite-dimensional cube). The attributes of autonomous cars are fixed by its creator, while the properties of the Hilbert cube are not fixed by anyone. Even if we happen to be great mathematicians, *we* do not decide the properties of the Hilbert cube—these are encountered as previously given data, which we merely discover. No mathematician will ever modify the topological connectedness and compactness of the Hilbert cube, whereas the bumper and load-bearing properties of the car could be different from what they are, and do very much depend for their effectiveness on the quality of the car-designer's vision. This reflects the fact that these two objects have quite different raisons d'être.

The Hilbert cube itself determines which descriptions can be attributed to it, possessing something within itself that fixes this such that it could not ever be otherwise. The car, on the other hand, being invented and constructed by engineers, could be different from how it actually is. This contrast makes them different in terms of their mode of existence: in Ingarden's own terminology, an autonomous car is a 'real being', while the Hilbert cube is an 'ideal being'. Reality and ideality are modes of existence. In order to determine what the difference between the two is, additional considerations of existential moments are needed, since modes of existence are precisely combinations of existential moments.

At the same time, for Ingarden, being-real and being-ideal were not the only such modes: he was able to distinguish many more through the recognition of ontologically simpler configurations from which they themselves were composed. What is more, as was already mentioned, his ontology is unfinished in the sense that it is open-ended: he introduced ontological tools which we ourselves can freely employ to distinguish even more modes of being—something that proves especially significant when it comes to the study of newly emerging phenomena such as virtual objects.

Returning to the issue of modes of existence, one might wonder whether this is something at all amenable to analysis: in other words, one might be tempted to assert that a mode, manner or way of existence, whatever it may amount to, is bound to be so utterly simple or basic as to be such that one should not expect to distinguish any aspects, features or properties specific to it. Yet we, like Ingarden, shall maintain the opposite: our position will be that each mode of existence is decomposable, inasmuch as it is constituted out of what he himself calls *existential moments*. These are comparable to pieces of, so to speak, the jigsaw from which existence itself is composed: they can combine to make up modes of existence—providing that they fit together properly in the sense of there being no contradictions between them. For our present purposes it will suffice to draw attention to those that figure in the four oppositions highlighted by him in the course of his own investigation, as shown below (Ingarden, 2013, p. 109):

1. existential autonomy—existential heteronomy;
2. self-sufficiency—non-self-sufficiency;
3. originality—derivativeness;
4. independence—dependence.

These oppositions can be regarded as furnishing the first (and elementary) level of explanation of possible dependencies between objects and, in particular, between objects and consciousness. Let us therefore say a few words about each of the existential moments they disclose.

As regards the first of the above oppositions, Ingarden (2013, p. 109–110) proposes the following definitions: "An entity (…) exists autonomously (is existentially autonomous) if it has its existential foundation within itself. And it has it within itself if it is something that is immanently determined within itself. On the other hand, an entity is existentially heteronomous (exists heteronomously) if it has its existential foundation 'outside of itself'". Amongst objects that are *existentially heteronomous* we encounter works of art, social institutions, the law, the characters in a novel, objects that are empirically possible (but non-actual, i.e., those not yet realized), and states of affairs. These are determined by something that is beyond themselves. By contrast, ideas (in the spirit of Plato), particular mathematical objects, ideal qualities (such as green per se) and real beings are *existentially autonomous*, as the source of their determination is immanent to them—they are, one might say, their very own source. Where virtual objects are concerned, our initial thought will of course be that they would have to be existentially heteronomous; nevertheless, this is something we shall hold open as we proceed with our discussion.

The *existential self-sufficiency* of an object is linked to the question of whether its existence depends on any other existence. Therefore, this existential moment is necessarily bound up with the broader existential neighbourhood of an object. To be more precise:

> An entity is existentially self-sufficient if in accordance with its essence it requires for its being the being of no other entity which would have to coexist with it within the unity of some whole, or, in other words, if its being involves no necessary coexistence with some other entity within the unity of a whole. In contrast, an entity is existentially non-self-sufficient if, as implied by its essence, its being involves a necessary coexistence with some other entity (which may have to be quite specifically qualified in its material essence) in the unity of a whole. Thus, for example, the moment "redness" is contained in a non-self-sufficient manner in the whole: "red color," since it must coexist with the moment "coloration" that occurs in the same whole (Ingarden, 2013, p. 147).

Another existential moment, i.e., *originality*, concerns the possibility of being produced. At first sight, this may well seem less than pertinent to our current deliberations:

> An entity is existentially original if (…) it cannot be produced by any other entity. In contrast, an entity is existentially derivative if it can be so produced. If an original entity exists at all, that is only because it is incapable of not existing in virtue of its very essence—provided there is such an essence, and more precisely, such an ideal "quiddity" as determines its nature (concerning which we render no decision here). And *if* it is so, then its own proper essence forces it to exist (Ingarden, 2013, p. 118).

An *existentially original* object, such as would satisfy the above definition, will be one that cannot be annihilated. There will be no beginning or end to its existence. It is, of course, natural to want to claim that virtual objects are not original, as they are produced by man. However, it is still quite natural to wonder whether all virtual objects can in fact be annihilated. A purely intentional object depends entirely on acts of consciousness for its emplacement and, so it seems, can thus be invalidated, as it were, by acts of consciousness and willing on the part of those artists who refuse to acknowledge it as existent. Yet it cannot be destroyed in the same sense in which autonomous existential objects are. The latter are *something*: i.e., they have an embodiment that can be destroyed. Purely intentional objects, on the other hand, even if invalidated, can still come to be intended anew as that which previously was invalidated. To be sure, an online shopping website is easily annihilated, but could *Pikachu* as such be so?[6]

The last of the above-mentioned existential moments concerns only self-sufficient objects. Some of these, despite the fact that they are self-sufficient, still by their very nature require other self-sufficient objects as a condition of continuing their existence. Following Ingarden, we shall say that these types of object are *existentially dependent*. For example, the existence of a human being, a self-sufficient object, requires the existence of a certain range of temperatures and the existence of oxygen.

With the basic existential moments defined, we can determine what the differences will be that pertain to the modes of real and ideal existence. The mode of real existence exhibits three varieties on account of time, these being *past*, *present* and *future*, and three additional cases by virtue of form, which are *persistent objects*, *events* and *processes*. Here we will only deal with persistent objects (Ingarden, 2013, p. 293–294). The mode of existence of present persistent objects consists of the following existential moments[7]: autonomy, derivativeness, activeness,[8] fissuration,[9] fragility, self-sufficiency and (in)dependence. Past persistent objects, meanwhile, define a collection of existential moments of the following sort: autonomy, derivativeness, post-activeness, self-sufficiency and independence. Finally, future persistent objects are determined by existential derivativeness, empirical possibility, self-sufficiency and dependence.

Ideal beings come in at least three varieties: particular ideal objects (like particular squares), relations among ideal objects, and ideal states of affairs or properties of ideal objects. Existential autonomy, originality, non-activeness, self-sufficiency and independence characterize the mode of existence of particular ideal objects. Relationships between ideal objects differ in that they are dependent. Ideal states of affairs are, additionally, existentially non-self-sufficient. It is worth adding that absolute being is characterized by existential originality, autonomy, activeness, non-fissuration, durability, self-sufficiency and independence. Ideas (that predetermine the objects that fall under them) also exist in an ideal way, which means that their mode of existence consists of existential autonomy, originality, non-activeness, and self-sufficiency. We can see that ideas exist in a similar way to individual ideal objects,

6 The possible annihilation of purely intentional objects has been discussed in phenomenological circles; see Ingarden's (1973, p. 124) discussion with Conrad-Martius.

7 The modes of existence, i.e. combinations of existential moments, given here are only a first approximation. Ingarden's ontology is open-ended, which means that it is possible to specify new existential moments as well as modes of existence.

8 Here we should add that activeness is an existential moment, and one that characterizes being in time (*in actu esse*). An object can be actual if it is subject to the passage of time and it is possible to distinguish, with regard to its existence, between past, present and future. Such actuality corresponds to fullness of being: the object is, so to speak, awaiting its actuality, which is located in its future, as only then will it be able to fully act.

9 'Fissuration' refers to the idea that an entity must exist in the gap between the past and the future. A fissure-like being exists in such a mode of being "that the individual phases of its fluctuating states must pass through just a *single* phase of activeness and then make room for the other states or phases of the evolving process" (Ingarden, 2013, p. 289). By contrast, a non-fissure-like being is one that can extend its present unlimitedly.

and yet there are differences between them at the level of their form. Ideas have a characteristic bilateral formal structure (which will be discussed below): ideas qua ideas, and the content of ideas. Particular ideal objects, on the other hand, are not bilateral in this sense.

When we focus on the difference between the most representative examples of real and ideal existing objects—i.e., the difference between a present persistent thing and a particular ideal object—we see that the ideal is original and non-active and not fragile, whereas the real is existentially derivative, active, and fragile. These are just the main existential differences between the ideal and the real. So, with these ontological tools to hand, let us now proceed to try to characterize intentional objects within the framework of Ingarden's ontology.

2.2 What Are Intentional Objects?

First of all, we should note that intentional objects are often interpreted as being no more than objects to which our consciousness happens to direct itself, inasmuch as we consciously entertain intentions that refer to them. For example, as we look at a book, it may well exhibit some characteristics that reflect our looking at it, and this might prompt us to say of it that it is an intentional object. Nevertheless, it is a contingent fact that we are looking at it, so these features surely cannot be counted amongst its ontological characteristics. After all, it does not matter to *the book itself* that we happen to be looking at it, and our so looking does not change anything about *it*. Thus, the most we can say is that alongside its being intentional in the properly ontological sense that we are concerned with, it is *also* intentional in this other (quite distinct) sense. Hence, for the sake of clarity, we shall sometimes refer to an object construed as intentional in properly ontological terms as a 'pure intentional object'. Ingarden (2013, p. 113) defines such an intentional object as "an entity which draws its being and its collective stock of attributes from the enactment (…) of an intentional conscious experience, which in a specific integrated fashion is endowed with a content, and (…) would not exist at all without this enactment". In this article, when we talk about intentional objects, we do not mean those that are *also* intentional, but just have in mind *purely* intentional objects.

Intentional objects do nevertheless resemble, so to speak, shadows inevitably cast by our acts of consciousness themselves. One might therefore suspect them to be purely subjective, and invariably dependent on the subject whose consciousness performs those acts. Yet that is not the case. Some intentional objects have their source directly in the acts of consciousness of a subject, while others have their source in other intentional structures (e.g., sentence meanings). (For example, Sherlock Holmes appeared in Arthur Conan Doyle's head—he was only a shadow, so to speak, of his creator's creative fantasy. As such he is purely subjective. But when he has become established as a character in a novel—that is, when sentences and larger parts of a text in the form of a novel assign him properties—then he becomes intersubjective. It turns out that prior to this he was, somehow, trapped in the author's head: being purely subjective then, he was imprisoned in a place to which no one else had effective access.) To distinguish them, the former is called the *primary* *intentional object*, the latter a *derived intentional object*. Of these, those of the second type will have a kind of borrowed intentionality, ultimately lent to them by the original acts of consciousness, but with bearers that are appropriate fragments of, say, the novel's text—or, indeed, of programs responsible for controlling certain computations. For the sake of this discussion, it can hereon safely be assumed that when discussing intentional objects the present authors are talking specifically about such derived intentional objects.

Intentional objects are double-sided and, in a certain sense, less than fully determinate. Let us begin with this latter property. We know, say, that Shrek is a green ogre, and that Fiona is his wife. However, we do not know, and cannot know, everything about Shrek, because we only know what is in the novel or film. What size waist does Shrek have, measured in centimeters accurate to two decimal places? Has he ever had hepatitis? We do not know. Where this fictional green character is concerned, we can only guess about (or ourselves stipulate) such properties. These areas of Shrek, which are not specified in the film or novel, are called "spots of indeterminacy" (cf. Ingarden, 1973; Laas, 2015). Intentional objects, in contrast to real objects, contain such elements of undefinedness. A real object, by contrast, is determined "in all its places". Turning now to the other property, we may note that their double-sidedness consists in the fact that where intentional objects are concerned, we encounter *two* subjects of properties. As an example, let us suppose that someone simply imagines Shrek. This imaginary Shrek will be the first subject of properties, and is just as it is imagined to be: a green and fat ogre. That is to say, *within* its imaginary content it counts as a real individual object that persists in time. Yet there is a second subject of properties here, too: this is the intentional object that is the pure imagining *itself*, which is not also something green and fat, but rather something quite insubstantial and subjective. This two-way construction of intentional objects is what distinguishes their form from that of other beings. By contrast, objects in the narrow sense (i.e., *mere* primarily individual subjects of properties) only have one subject of properties.

As we have mentioned, intentional objects are heteronomous, because the basis of their determination lies outside of them. They are also non-self-sufficient, in that their existence requires either acts of consciousness or some other existential foundation (such as a real book, or some instance of naturally occurring computation). Moreover, they are not original, as they have been produced, and are not dependent, because they are not self-sufficient (see Skowron, 2020). Their manner of existence is thus a very weak one, especially when compared to real objects that exhibit autonomy, derivativeness, activeness and self-sufficiency, or ideal entities displaying autonomy, originality, non-activeness and self-sufficiency.

2.3 Virtuality and Intentionality

Our thesis, then, is that CVOs are not simulations or interactive objects, but intentional objects in the sense outlined above. They are man-made, and so not existentially original. They are created at a specific time—though, like other intentional objects, it is not clear whether they perish. (Can Hamlet, or the weapons in

Counter-Strike, be annihilated?) Their content is given to them—for instance, by a programmer; they are not the foundation and source of their own content. The source of CVOs' existences are the acts of consciousness of their creators, as without these acts they would not exist, while they have their existential basis in computational processes, as it is thanks to these that they remain in existence. We understand the grounding of CVOs in computational processes ontologically as one-sided existential non-self-sufficiency. The essence of CVOs requires their being to involve a necessary coexistence with certain computational processes within the context of the unity of a whole, but not vice-versa. The latter point entails, in turn, that CVOs possess an existence framed by certain models of computation, as described below. Yet we may wonder, are CVOs only intentional objects—that is, mere shadows of the activity of consciousness, sustained in existence by such computational processes? We ourselves would reject such an assertion. As has been shown (see Skowron, 2020; Chalmers, 2017), CVOs are in fact situated within a process of becoming part of the real world. We shall now take a closer look at how this could be the case.

Just like Shrek, Hamlet, or Mozart's "Prague" Symphony, CVOs are a result of human creativity. Nevertheless, their visible impact on the real world is so strong that some, like Chalmers (2017), even claim that they are just straightforwardly real. Hamlet, though, is unfortunately not real: rather, he is an intentional object permanently located within Shakespeare's tragedy, which can have its own (or other) real incarnations on the stage of this or that theatre. Despite the fact that he helps to create our culture, he remains a fictional character, and no one would attribute reality to him. Yet this is not the case with all virtual objects. Let HoloFoldit—so far only a hypothetical application, but nevertheless interesting from a philosophical point of view—serve as an example.

HoloFoldit is a hypothetical system proposed by Paul Smart (2022). The idea is based on the HoloLens, a mixed reality device designed by Microsoft. It is projected that the user mounts the HoloLens on their head and can thus interact with both real objects positioned around them, and virtual objects (in this case holograms) produced by the HoloLens. The latter are rendered at specific physical locations, so that a user in the room can actually walk around a stable hologram of this sort. They can view the hologram as they would view a real sculpture on display in an art gallery. Using gestures and voice commands, the user can manipulate the holograms—moving them around, for example. Thanks to its Wi-Fi connection the HoloLens has access to online services, and thanks to the possibility of being connected to the Internet of Things the user can interact with the actual physical surroundings of the hologram: for example, by using special "buttons on the hologram" he or she could cause the actual lighting of the hologram to change, increasing its visibility.

Smart then goes further, and proposes considering the HoloLens in a specific form: i.e., as the hypothetical cognitive system HoloFoldit, which combines the HoloLens with the actual Foldit app used by structural biologists to solve the protein folding problem. The problem of protein folding is extremely complex. Hence, the Foldit app combines, in a way that exploits their complementarity, the user's cognitive potential (e.g., perceptual abilities and spatial reasoning)—which, for example, serves to reduce the space of possible searches—with computational methods, such as local optimization or reconfiguration. In this way, it amounts to an interactive optimization system: a kind of bio-technological symbiosis (Smart, 2022). At the same time, Foldit is not passive: it can even propose to the user to engage in certain activities.

Smart (2022) proposes that we think about such a hypothetical HoloFoldit application for philosophical purposes. It is a potential combination of the HoloLens with the functionality of Foldit. The user would be able see the structure of a protein as a hologram in the space in which they were located. They would be able to rotate this hologram, move it around, add more parts to it, and even, as it were, go inside it—something that a representation of a two-dimensional image in the Foldit app alone would not be able to convey. Using online libraries of computational procedures, the user would have computational support, just like in Foldit. A philosophical question then naturally arises: what would the kind of cognition realized via the HoloFoldit system then amount to? Would it be cognition on the part of an individual person only? It would seem not. Smart (2022) rightly states that "the process is being performed by a larger systemic organization that includes the human individual, the HoloLens, the holograms, and a suite of online (Internet-accessible) computational routines". Smart has shown that this larger whole is an example of hologrammatically extended cognition: i.e., cognition that goes beyond the limits of the human skull. But what implications does this have for virtual objects?

Firstly, what the user will perceive in HoloFoldit is the holographic protein molecule, which must be constantly adapted to the user's expectations and choices, but also to the constraints of the problem being solved. We can also assume that some version of this application will use machine-learning algorithms that will engender user-independent yet problem-solving-enhancing changes in the computational procedures used. This customization process is akin to its actualizing itself. It seems that this hologram has a past, has a future as well, and is *actual* in the present. This constant actualization, together with the fact that the hologram occupies (albeit only in a weak sense) space, makes the virtual object (in this case the hologram) real. Secondly, Smart (2022) spells out certain causal dependencies: "the act of walking around the holographic protein molecule does involve a causal link between the human observer and the perceptual object, albeit one that is mediated by the HoloLens device". Causal relationships are the domain of real being—hence Smart's suspicion that causal relationships exist between virtual objects and real objects. He describes in detail sequences, causal loops (e.g., human → HoloLens → hologram → human), and even "dances", in which all components of the HoloFoldit mechanism are involved. The causal impact would be further amplified if the Internet of Things were used. Thirdly, the cognitive system encompassing the Holofoldit application is a certain whole and its components are its imperishable parts. The human person is part of the HoloFoldit mechanism, as well as the HoloLens, the holograms and the computations carried out online. If we accept this claim that we are dealing with a single whole, then we would say that this whole is real: the human person, the HoloLens, as well as the computations performed, although different in form, exist in a real way. Each part of the real object—that is, each component that the object has as its property—should exist in the same way that the whole exists. Therefore, again, we arrive at the conclusion that holograms, or virtual objects, are real—or at least *become* real. All three of the above points are thus indicative of a process of making virtual objects real.

Intentional objects, because they possess spots of indeterminacy and have their attributes assigned to (or 'intended' in respect of) them when not embodied, are, as Ingarden (2013, p. 115) claims with reference to Husserl, objects without an *essence of their own*: i.e., without an ensemble of qualifications such as could be said to be wholly immanent. Now, if one accepts that what enables some object to be picked out from amongst others is the essence of the entity in question, then it seems that we are able to identify HoloFoldit in such terms, and that in this sense it must be deemed to possess its own essence, making it closer to something real than something merely intentional. Heteronomous objects have no essence at all: Ingarden is clear that "only autonomous entities can have a proper essence" (Ingarden, 2013, p. 115). Hence the conclusion that HoloFoldit, being previously built from also intentional objects, has embarked upon a process that constitutes a kind of existential autonomization. The factors supporting this autonomization are, for example, user interaction and the possibility of machine-learning procedures. The more it has its own attributes, genuinely embodied in it and not merely intentionally assigned to it, the more it becomes autonomous. Thus, the process of autonomization does not resemble a leap, but rather a continuous transition, making virtuality itself into something gradational, whose intensity decreases as the autonomization process progresses.

We imagine Sherlock Holmes to be a man, and to be a real man. We assume, say, that he is an effective and well-trained hand-to-hand fighter of above-average physical strength, and that he is in possession of a certain height—not to mention his remarkable abilities when it comes to deductive reasoning. However, none of these properties are actual in the way that, say, the properties of the bicycles on which we travel to work are; instead, they are imparted to him by Conan Doyle's creative fantasy. The acts of consciousness that create Holmes bring about nothing more than what they themselves impute. Such acts cannot impart immanent attributes to Holmes. In other words, as Ingarden (2013, p. 116) puts it, "the poetic, creative act of consciousness can produce [*schaffen*] no existentially autonomous object" and, as he continues, "[t]hat act is 'impotently creative'—what is produced by it lives by the grace of the conscious act producing it, and it cannot make itself 'self-willed' [*eigenwillig*], 'independent', 'sovereign [*selbstherrlich*]'. It cannot 'rebel' against the corresponding acts of consciousness—it can have no properties, no self-chosen vicissitudes of its own, other than those that are allotted to it."

At this juncture, we might also consider machine-learning algorithms, such as are used in autonomous vehicles (Bojarski et al., 2016). These are intentional, man-made objects that can nevertheless oppose the will of some human being or other. Such vehicles can rebel against certain acts of consciousness and decide for themselves which solution—which route—to take. Similarly, chatbots also demonstrate a high degree of independence from their creators when it comes to generating unique content—something they themselves can also then further enhance. This is another manifestation of autonomization, understood in an existentially strong sense: the more they rebel, the more they become existentially autonomous. Once again, we are dealing with an intensification of existence, and at the same time with the existential nature of virtuality as something gradational.

We shall now move on to a consideration of the ontological foundations of virtual objects: i.e., the computational processes that ground them, and the models of computation realized in them. On the other hand, models of computation are not arbitrary objects: they fall under their ideas—which means, amongst other things, that their ideas predetermine them. In this way, we hope to provide an ontological framework for determining both the necessary and the possible states of CVOs.

3 The Computational Basis of CVOs[10]

3.1 Computational and Phenomenal Properties of CVOs

CVOs have two types of property, this being a reflection at a still deeper level of their two-sided intentional structure. First, there are internal, *computational* properties, which are related to the structure and functioning of the computational procedures that define a given object. One should keep in mind, though, that computational procedures are defined at different levels of abstraction: from the least abstract machine code, through descriptions in high-level programming language (e.g., C++) that are much more abstract (albeit better understood by designers), to the most general specification of the desired functions of a given CVO (Turner et al., 2019 and Primiero, 2016). These computational properties include, for example, the type of computation determined by a certain theoretical model (e.g., digital as distinct from analog computation), or the time complexity of procedures controlling CVO behavior, which informs us about how quickly individual functions of the CVO can be performed. Second, there are external, *phenomenal* features, which are revealed only in the relations between the CVO and its observers or users. These include appearance (e.g., the scenery of a computer game as perceived by the user), interactivity (e.g., the scope and degree of interaction between the CVO and the user) and ergonomics (e.g., ease of use). However, the very nature of the CVO is itself determined by its computational features—features whose existential basis in the form of some appropriate computational procedure or other is also the basis for the continuation in existence of the CVO itself. It is one thing to enter into existence (i.e., existential heteronomy), and it is another to stay in existence (i.e., existential non-self-sufficiency). It is for this reason that we are inclined to regard taking immersion to be a constitutive feature of all virtuality as being misconceived.[11] The latter is created

[10] Parts of Sects. 3, 4 and 5 here are revised and extended versions of sections of a paper previously published in a language other than English (see: Stacewicz, 2019).

[11] Chalmers (2017) arrives at a similar thesis: for a broader analysis of virtual reality, immersion and non-immersion are not constitutive. However, as was pointed out by one of the anonymous reviewers of this paper, we must add that for certain types of CVOs (but not CVOs in general) immersion is a constitutive feature. This is the case with three-dimensional CVO objects, which are elements of virtual-reality systems and are displayed in physical space as interactive holograms (Smart, 2022). Hence, our thesis of non-constitutive immersivity does not apply to all intentional objects.

at the intersection of the conscious user's experience with the appearance of virtual objects, but is hardly relevant to the underlying foundations of their existence. It is comparable to the continuous appearance of a table generated when one looks at the latter while perambulating around it, this being not the essence of the table, but rather the result of an individual and subjective experience of it. Were this not to be the case, we would have as many tables as there are subjects walking around a given table—a sure recipe for madness.

3.2 Levels of Description of the Computational Properties of CVOs

Computer science, which provides a theoretical framework for designing and constructing CVOs, itself has a 'dual nature' (Turner et al., 2019; Hartmanis, 1995). On the one hand, it is partly a formal science related to mathematics, and thus to the ideal, and on the other, it is in part also a technical science oriented towards the construction of physical devices, these being mainly computers, and thus is close to the real. Taking this into account, and slightly extending the perspective, we shall distinguish three different aspects of CVOs, which will allow us to analyze their computational features at three distinct levels:

A. The model of computation—i.e., the level allowing one to indicate one of the possible elementary data-processing models with which a computational procedure is compliant (for example, a digital model). This procedure is representable as a set (or sometimes a sequence) of basic instructions and/or structures for a given model. The ontological condition for the existence of a CVO will be the existence of that particular procedure, compliant with the given model.[12]
B. The programming language—i.e., the level at which the computational procedure is understood as a set of instructions in a specific programming language (such as Pascal, Prolog or C++).
C. The physical implementation—the level at which the computational procedure is understood as a sequence of physical states of a certain type (e.g., electrical impulses) inhering in the elements of a given physical system (e.g., a microprocessor); such states enable the intersubjective character of the CVO (i.e., it becomes a derived intentional object), and at this level it is possible to uncover its causal powers.

It is worth stressing here that the term 'model of computation' is understood broadly in this work, not limiting its scope to standard models fulfilling the

[12] The most basic mathematical property of these models is the type of numerical code (to be more precise, the type of numbers) employed—where, in the context of a mathematical description, this is what corresponds to the relevant computational procedure. Especially important here is the distinction between discrete (natural-numbered) codes and continuous (real-numbered) ones. The type of code is associated with the type of mathematical functions that correspond to the computational procedures. For discrete codes, these are traditional recurrent functions (or a subset thereof), while for real-numbered codes they are real recurrent functions (allowing operations in continuous domains) (cf. Costa and Graca 1993).

Church-Turing thesis which are extensionally equivalent to the universal Turing machine. Thus, in the understanding adopted here, computations also include non-Turing ones, described mathematically by means of such models as analog or infinitistic models (see point 4.1).

Models of computation, viewed from an ontological perspective, are ideally existing objects, where this means, amongst other things, that they are autonomous and existentially original. They differ from each other (e.g., analog vs digital models), and this corresponds ontologically to the fact that they fall under different ideas of models of computation. Particular models of computation are *particular* ideal objects. Ideas are *general* ideal objects. This is the main difference between ideas and particular ideal objects. The world of ideas is ordered according to the generality of ideas: there are more general and less general ideas. The world of particular ideal objects, by contrast, is not ordered by generality: in this respect, all individual objects are "equally particular". Viewed from an ontological perspective and roughly construed, the Church-Turing thesis affirms a relation of identity between the content of certain ideas: the idea of a universal Turing machine (and equivalent models) and the idea of effective computing.

Much as with Ingarden's arrival at a taxonomy of modes of being through the combining together of consistent existential moments, we can, given the levels just specified, distinguish between different types of CVO as being determined by different properties of the computations. For example, some object *P* may be digital (because of the model of computation involved), object-oriented (because of the type of programming language in which it is described), and electronic (because of the type of physical processes used for encoding and transmitting the data). Meanwhile, some other object *S* may be quantum (because of the fact that the object is constituted by quantum computation) and optoelectronic (in that the physical basis of computation is different from what it is in the case of *P*).[13] The same will be true, moreover, for other intentional objects that inherit certain traits from their existential foundations: a literary character, for instance, is literary just because of its being described in a literary work. As Ingarden (1973) in fact himself sought to do, these can be divided into levels directly relating to their nature. Specifically, a literary work will contain layers consisting of verbal sounds, units of meaning, schematized aspects and represented objects.

In this regard, we should also note that the characteristics proposed above are sufficiently broad to allow for the existence of items compliant with multiple different models of computation, including *non-digital virtual objects* (although the possibility of their physical occurrence raises certain issues to be addressed below).

[13] In this case, the type of programming language cannot be indicated, because the programming of quantum circuits is as of now insufficiently developed, and the relevant languages do not yet exist.

4 Models of Computation, Their Ideas, and the Properties of CVOs

4.1 The Ideal Predetermination of CVOs

The reader will recall that given the computational nature of CVOs, their basic computational properties depend on the model of computation involved, where this will predetermine the type and organization of elementary computations.

These basic properties do not determine all of the features of a CVO; however, they do determine, for instance, the way in which it is recorded or copied. They also determine—or, to be more precise, predetermine, thanks to a specific model of computation—certain general limitations for objects of a given type: namely, certain actions that cannot be performed by or within them. For example, digital objects (existing and running on the basis of programs for digital machines, compliant with the Turing model of computation) cannot solve the halting problem, or the problem of Diophantine equations (Harel, 1987). This follows from the properties of the model (ideal object), and a man can grasp and prove it mathematically—through, for example, a diagonal proof for the unsolvability of halting problem (Turing, 1936/37). Consequently, it is not possible to perform activities that require the solving of these problems. Other limitations relate to the practical impossibility of solving certain problems (rather than their impossibility in principle), which in turn hinges on their mathematically graspable temporal or spatial complexity. For example, a problem with exponential complexity in respect of time, such as the Traveling Salesman Problem, cannot, starting from a certain data size, be solved in practice by any computational procedure that falls under the model of digital computation, due to the extremely long computation time involved. It could, on the other hand, be solved by procedures that fall under the model of quantum computation, as this type of computation allows for[14] the exponential time-complexity barrier to be overcome (Deutsch, 1985). Consequently, quantum virtual objects could perform tasks that require solving the Traveling Salesman Problem, whereas digital virtual objects cannot. Such tasks could concern, for example, the search for the shortest round-trip route for n cities (places) within a digital virtual object such as the Google Maps application.

From the perspective of Ingarden's ontology, at least, the models of computation are objects existing in an ideal way, and their possible behavior is determined by the appropriate ideas. Ideas as such, according to Ingarden, have content that determines their possible references to objects falling under them. The content of an idea is a specific set of (necessary) dependencies, such that all objects (including ideal objects) falling under a given idea must, of necessity, fulfil these dependencies. In our case, these are the dependencies obtaining between elements of the model of computation (such as the contents of the tape, and the movement of the head, in the Universal Turing Machine model) and between a specific problem domain and the flow of operations within the model. Hence, we may assert not only that the virtual

[14] We write "allows for" here, because a necessary condition for a real surpassing of this barrier would be the development of an effectively realizable quantum computing technology.

objects under consideration here straddle the boundary between reality and fictionality, but also that, as one might say, they are hostages of ideal beings—or, more precisely, that they participate in the latter's ideas. In these objects, the appropriate ideal qualities, in the sense of the components of the content of their ideas, are concretized. These ideas determine both the scope of their possible invariance and the relationships that necessarily obtain between their components. Ontologically speaking, one may say that all the possible ways in which a computational virtual object may behave are indirectly predetermined by the content of the relevant idea.

Failure to take due note of this ideal form of predetermination constitutes a significant shortcoming where the study of virtuality is concerned, as it leaves unacknowledged certain relationships to which a virtual object is necessarily exposed. At the level of our own experiences, the equivalent of these relationships is not so much the much-glorified one of immersion as, more often, the sense of sheer annoyance we feel as users when, in the absence of any other possibility, we are obliged to go through the subsequent stages of a certain procedure. And it sometimes happens that the user cannot do something, in that this is simply excluded by the content of the relevant ideas: much as when we come up against a contradiction, for instance. Of course, this is not to deny that for some users, the experience of necessity that arises in our dealings with machines themselves will count as something to be affirmed and enjoyed in the purest terms—in that for such a platonic user, the sheer order of necessity itself will count as the most beautiful thing in the world.

4.2 Turing and Non-Turing Models of Computation

Within the broad field of theoretically construed models of computation, special attention should be paid to the distinction between the *Turing* or digital model,[15] described formally under the framework of the Universal Turing Machine, and *non-Turing* or non-digital models, which refer to various types of hypercomputation (Ord, 2006).[16] Since the digital model is widely known, it need not be described here (see, e.g., Turing, 1936). However, it is, we think, worthwhile devoting some space to instances of the second type of model, especially with a view to pointing out a certain general strategy for defining these. This strategy consists in extending the idea of a Turing model by modifying at least one of its key features, where the latter are as follows:

a) *discreteness* (with respect to the data and states of the processing system),

[15] It should be made clear that in the context of the present article, digital computing is understood more narrowly than discrete computing. Forms of the former are theoretically described using the model of the universal Turing machine, and are implemented in practice using digital machines (with different architectures and technical parameters). Discrete computations—such as involve the processing of distinguishable elements (symbols) by means of mechanisms with distinguishable states—include not only digital/Turing computations, but also infinitistic and strictly non-deterministic ones.

[16] It is worth noting that the vast majority of data-processing systems currently in use, and therefore also the vast majority of virtual objects created using these, are digital (i.e. compliant with the Turing model at the basic level of computation).

b) *finiteness* (a finite number of operations performed in a finite time), and
c) *determinism* (a well-defined data processing scheme).

We shall now seek to explain this in more detail with reference to the above:

as regards (a), replacing discreteness with some broader property of data-related continuity furnishes us with a model of analog-continuous computation (usually simply called 'analog') of the sort that makes possible the processing of continuous signals, these being described mathematically with the use of real numbers;
as regards (b), rejecting finiteness as a feature of computation in favour of its construal as infinite makes it possible to define different models of infinitistic (hyper) computation, in the sense of those that allow one to perform an infinite number of operations in a finite time;
as regards (c), jettisoning the requirement of determinism in respect of subsequent steps of the process of computation leaves us with a model of indeterministic computation, such as depends for its course on the occurrence of random events.

If we wish to grasp how the above-mentioned general distinctions are operative in the context of actual research, it is worth mentioning specific examples of each type of technique. Analog techniques include some generalizations of the traditional Shannon model (Pour-El, 1974; Shannon, 1941), as well as processing schemes specific to the idea of recurrent neural networks (Siegelmann, 1998); meanwhile, infinitistic techniques include the hypothetical computations of so-called 'accelerating' Turing machines (Shagrir, 2004) and 'relativistic' Turing machines (Hogarth, 1994), while non-deterministic techniques certainly include quantum and evolutionary forms of computation (Michalewicz, 1992).[17]

Summarizing, we may conclude that there are different types of computational virtual object, determined by different models of computation, which fall under different ideas. Ontologically speaking, it can be asserted that through the relationships obtaining between their contents, the ideas of the aforementioned models predetermine certain types of intentional object.

4.3 Why Are Non-Turing Models of Computation Ontologically Important?

Although theoretical considerations allow for the possibility of conducting non-Turing computations, and thus for the possibility of the existence of CVOs other than digital ones, from the point of view of their practical implementation, the issue

[17] It is worth noting that the computing techniques mentioned in the above points are known as instances of 'hypercomputation' due to the fact that they are theoretically stronger than Turing computation. They are so in that they either allow one to solve problems incomputable under the Turing model (such as the halting problem), or permit one to solve problems that, under that model, are incomputable in practice (because, for instance, they exhibit exponential time complexity). The latter possibility pertains to quantum computation.

seems as yet unresolved. The negative conclusion (to the effect that non-digital CVOs cannot exist) is supported by the famous Church-Turing hypothesis, which has not been mathematically proven, but nevertheless has received a good inductive justification (Harel, 1987).[18] In one version, this thesis says that "a function is effectively computable if and only if it is computable using a universal Turing machine", which can be interpreted as meaning that in no effective—that is, practically computable—way of computing other than the Turing machine will it ever be possible. In other words, all physically feasible models of computation are taken to be computationally equivalent to the model expressed in terms of the universal Turing machine. If this thesis were true, virtual objects would then have to be such that all their real counterparts (i.e., virtual objects already subject to a process of making them real) would have to meet certain limitations imposed by the Turing model, so that—ontologically speaking—the content of the idea is understood to determine certain necessary relationships between the components of all possible and practically constructible virtual objects.

With reference to the strategy of expanding the Turing model, we can explain what the ontological difficulties are with the actual (and not only the theoretical) existence of non-digital CVOs. These stem from the fact that the theoretical concepts of continuity (the basis of the analog techniques), infinity (the basis of the infinitistic techniques) and randomness (the basis of the indeterministic techniques) need not necessarily correspond to the world from which the real data carriers processed by real devices have to come. For example, if the real world necessary for the realization of computation were to be discrete (quantized) and finite in every respect, then it would not be possible to construct any analog or infinitistic systems (despite having a perfectly good mathematical theory for the appropriate form of computation). For this reason, it would not be possible for there to be any CVOs corresponding to these systems or depending on their operation.

Despite our state of ignorance regarding the possibility of the physical existence of CVOs that are other than digital (in that the Church-Turing thesis remains an unresolved matter), from an ontological standpoint, considering alternative non-Turing models of computation still looks to be a valuable exercise. We can treat these models as realizations of ideas that may or may not be involved where real CVOs are concerned. By studying some of their formal properties, we can obtain in advance important information about certain features of potential CVOs, doing so without prejudging the physical feasibility of some or all of the relevant models of computation. From an ontological point of view, such work—which is in fact mathematical—is certainly not to be dismissed. Ontology as such examines pure possibilities and the necessary relationships between them. In the case of virtual objects subject to a process of becoming real, thanks to formal and ontological analysis, we can know in advance what *may* happen. In particular, computational virtual objects

[18] The point is that all mathematical models of universal programmable machines (which allow one to solve problems algorithmically) so far have been proven to be equivalent. In particular, they are equivalent to the Turing model.

can never exceed the limitations imposed by their respective ideas of models of computation.

5 Natural Computing, and the Dependence of Some CVOs on Nature

5.1 Types of Natural Computations

A separate group of computations—separate, that is, in the sense that it is not yet known to what extent their individual typologies can be captured using the above-mentioned models—consists of so-called *natural computations*. This term refers broadly to the following: computations inspired by the observation of nature but without explicitly using observed natural processes (e.g., evolutionary ones, based on genetic algorithms), computations performed in ways that make use of naturally occurring processes and/or mediums (e.g., quantum ones), and processes occurring within nature itself (e.g., intra-brain processes) (Kari & Rozenberg, 2008; Rozenberg, Back and Kok, 2012). It is also worth mentioning here that within the contemporary philosophy of nature, there is a standpoint known as pancomputationalism, at the core of which lies the assumption that all natural processes possess a computational character (see the third of the above-mentioned possibilities), and that they can be adequately described by drawing principally on concepts and models from computer science (see the first and second possibilities mentioned above) (Polak, 2017; Zenil, 2013).

Amongst natural computations, of particular interest in the present context will be those computations that are produced by humans, so that they do not count as natural in the pure sense of enjoying an existence in nature independent of human beings, but which nevertheless involve natural substrates and/or processes, and do so in a significant way. Here, it is necessary to draw attention to the phrase “in a significant way”, as this is meant to convey the thought that the effectiveness of systems based on this type of computation (e.g., as regards the time required for task completion) depends significantly on a particular reference to nature. The computations thus described include, on the one hand, *quantum* computations referring to the properties of inanimate nature (in that these are effective just inasmuch as they are carried out with the direct use of quantum phenomena), and, on the other hand, *biological* computations that use organic matter, such as DNA-based computations (de Castro, 2007; Rozenberg, Back and Kok, 2012). It seems that this same group also includes traditional analog computations involving macroscopic physical processes: e.g., naturally occurring changes to electromagnetic fields within specially selected systems. Such processes allow one to determine the results of various kinds of integration, differentiation, etc., directly, without recourse to digital simulations (Shannon, 1941).

While natural computing counts in the current context of applied computer science as a rather exotic field, given certain preliminary results (Kari & Rozenberg, 2008; MacLennan, 2004) it seems reasonable to assume that computer systems will, in the future, use ‘natural’ solutions to at least some extent. Therefore, serious consideration should also be given to CVOs based on natural computations.

5.2 The Gradational Character of References to Nature

Due to the potential importance of natural computations, we shall assume that due to certain physical prerequisites of natural computing also, virtuality is a gradational feature. What we have in mind here, to be more precise, is the gradationality of the references to nature necessarily involved—such that the more references a given CVO requires to fulfil its functions, the more real it will be, and thus also the less virtual, too.

It is clear that at the level of the real implementation of computations (and therefore also of the virtual objects coexisting with them), there is a certain dependence of computations on the properties of nature; this is due, for example, to the choice of a particular data carrier. In the case of natural computation, however, this dependence is more fundamental, since it is strongly grounded at the level of the model of computation itself. This model may contain some necessary reference to regularities in the real world, which are described by the relevant laws of empirical science, such as the laws of quantum mechanics. The narrower the scope of the mentioned regularities and laws, and therefore the more specific the systems or processes that have to be used, according to the model, in order to realize the computation in an efficient way, the greater the dependence of the computation on the properties of the world. For example, the model of quantum computation refers to regularities and laws that are more general (laws of physics) than some models of biological computation; the latter, therefore, require the realization of computations by means of more specific (also more complex) systems and processes. Consequently, in turn, quantum CVOs are less dependent on the properties of nature than CVOs based on the idea of biological computation. Note that the criterion sketched here—the one for stating the greater or lesser dependence of CVOs on properties of the real world—applies not only to computations of the sort that are called "natural", but also to other computations, including digital or analog-continuous ones.

It follows from the above considerations that if different (not exclusively digital) models of computation were to be physically feasible, then depending on the idea of the model describing a given CVO (or, more precisely, the one capturing the computation that underlies it), this object would have to be more or less dependent on nature.[19] The minimum dependence, and thus the maximum degree of virtuality, is provided for by the digital (Turing) model: in this case, it is enough to use two distinguishable states and some very simple processes, such as *move the reader right or left* (when referring to the Turing machine model, that is, and not to real, physically and technologically advanced computers). Importantly, these states and processes, according to the theoretical model, do not require the use of any special physical substrate. A more significant dependence on nature, meanwhile, is necessitated by the idea of an analog-continuous model: for its realization, it is necessary to 'take

[19] It should be emphasized that what we are talking about here is a form of dependence construed as obtaining on an elementary level (as reflected in a given model of computation), and not merely the degree of physical complexity that real devices happen to be exhibit when realizing computations described by a given model.

out' from nature a certain physical medium possessing an unlimited range of distinguishable states (Stacewicz, 2020). If such a medium did not exist in a real manner, every practical realization of this type of computation would in effect reduce the latter to a digital one. (In other words, the theoretical analog model would have no real equivalent.) At the same time, an even greater dependence characterizes computations that follow the idea of a quantum model: their effectiveness and efficiency requires specifically that such quantum microstructures, and no alternatives, be used. Were we not to take these from nature, we would be unable to overcome the limits imposed by the exponential time complexity that affects certain problems (Deutsch, 1985).

To sum up, even if we consider computations in purely theoretical terms referring to different models of computation falling under the idea of computation of a certain type, the various hypothetical computation types we can conceive of will impose specific 'constraints' on CVO's themselves, making them more or less dependent on nature.

Where applied computer science is concerned, current practice does indeed appear to lend further support to the above arguments. It turns out that when attempting to solve difficult optimization problems, computer scientists increasingly have recourse to nature: that is, they 'calculate' by using quantum microcircuits or biological systems such as DNA chains (Kari & Rozenberg, 2008, p. 78). In this way they engender objects that, because of the fact that they are dependent on nontrivial properties of nature in respect of their manner of existence and operation, cannot be said to be entirely virtual.

In conclusion, it must be stated that in the field of CVO design and implementation, and from both a theoretical and a practical perspective, a scale of gradations can be observed with respect to references to nature: the greater the dependence of the structure, course and effectiveness of computation on non-elementary properties of nature, the more natural, and so less intentional, the computation should be regarded as being. As a consequence, computationally grounded CVOs may rightly be regarded as being more or less virtual.

6 Back to Ontology: Virtuality as a Gradational Feature in the Existential Sense

The foregoing arguments pertaining to models of computation show that at least some theoretically possible CVOs are dependent to a greater or lesser extent on processes occurring in nature, such as quantum phenomena (and with the degree to which this is the case being determined by the relevant model). On the one hand, these natural processes help to increase the effectiveness of CVOs' control procedures, while on the other, they impose physical limitations on CVOs themselves. These physical limitations are due to the fact that natural computing—so long as it is not to be reducible to digital computing—must be implemented using specific physical states and processes, governed by specific laws of empirical science. The latter form of dependence imposes certain limitations—greater than in the case of classical digital computation—on the products of consciousness that create virtual objects. It therefore limits the potency of intentional acts of consciousness. What is more, the foundedness of certain virtual objects in nature may actually make it a great deal easier for them to become existentially autonomous, where this in turn may include becoming real in the sense of coming to exert a physical influence upon the natural environment. This is particularly evident in the case of computations involving natural substrates, such as real DNA chains or whole cells of living organisms. Such an observation can, once again, open the way to some more general considerations of an ontological nature.

The ontological properties of CVOs' computational foundations allow for a specific stratification of the intensity of CVOs' existences. Some CVOs will be similar to created objects not rooted in any real objects, these being pure phantasms that cannot ever become real. An example of such objects would be virtual swords, acquired by players over the course of a computer game. Nevertheless, others will be much more closely related to real objects, and it can even be said that as an intentional object such a CVO changes its way of existence, becoming real and turning into a part of the real world (Skowron, 2020). Consider, for instance, Google Maps, which as a virtual object may help to bring about the unblocking of traffic jams in one part of a city while creating them elsewhere. The process of becoming real is based on the fact that the CVO becomes existentially autonomous: the more it becomes existentially autonomous, the more real it is.

Becoming real is also possible thanks to the temporal specificity of virtual objects, as was stated in (Skowron, 2020). CVOs have a certain temporal structure: in particular, we can distinguish their past, future and present states. Being actual is specific to real objects (to the exclusion of ideal ones), so if some CVO turns out to be actual, it will also be real. In the context of Ingarden's ontology, at least, the actuality of some being or other corresponds to its acting (in a direct and immediate sense). As seems to be the case with Google Maps, where virtual objects are directly present, they themselves are sources of action, and on this basis count as actual (for more details see Skowron, 2020).

At the same time, it should be noted that, contrary to Ingarden's ontology, where the existential autonomy of a given object stems from its essence, the very nature of the computations that constitute a CVO may determine its greater or lesser degree of autonomy. This applies both at the level of the model of computation, in that some properties of the model as an ideal object necessarily imply a certain CVO, and at the level of specific algorithmic techniques, because, for instance, the use of self-learning algorithms makes certain CVOs become more and more independent of the intentions of their creator. The only limitation imposed by the ideal being is that which consists in the fact of its predetermining the totality of possible solutions: it will not predetermine the specific solutions applied by a given CVO.

Of course, as we have just mentioned, the process of becoming real also has a physical undergirding. Becoming real can be more or less 'facilitated' by the use of one type of computation or another, where such computations are responsible for both the changes in the object over time and its potential impact on the physical environment. If we focus our attention on the second element, we cannot fail to note that the greater the rootedness of computations in nature (i.e., the more natural those computations are), the easier it will be for a given CVO to become real in the sense of exerting a real influence on its natural surroundings.

If the above ontological analysis is correct, then the way in which CVOs exist should strike us as somewhat surprising: in spite of being ruled out as a possibility within the ontology of Ingarden, at least some CVOs are, in fact, objects that can change their way of existence. If an object changes its way of existence, it loses its identity. It is no longer itself. In this sense, then, we would have to say that a virtual object that has become real is already another object, and not the same one that it was before. Such ontologically fundamental transformations are bound to be a source of surprise for both IT-based ontologists and classical metaphysicians. CVOs thus turn out to be objects of a kind that call for new ontological research to be undertaken into questions of identity. For example, could the very existential identity of some being or other be a gradational matter, just as its existential autonomy is?

7 Conclusions

Our thesis has been that virtuality straddles the divide between reality and fictionality, it being anchored, ontologically, at one and the same time in both top-down and bottom-up terms. In the former case, thanks to the computation models realized within it, it is so in an ideal mathematical being. In the latter one, through both the references to nature involved in natural computations and processes of existential autonomization, it is so in real being. Thus, if we try to make sense of virtual objects in terms framed by an overly simplistic opposition between the real and the virtual, or study it through what are, in many cases, incidental properties such as simulation, immersion, and interactivity, we will be guilty of flattening out significantly the ontological multidimensionality of virtuality. What is more, our proposed approach to virtuality has led to a recognition of it as a gradational mode of being, with the intensity of being of a given virtual object depending on its degree of existential autonomy/heteronomy and the degree of 'naturalness' of the computational processes on which it is based. Put more generally, it should now be acknowledged that an object may be virtual to a greater or lesser extent. The more it is based on natural computations (and here we should remember that different models of computation assume a different range of necessary references to nature), or the more it becomes autonomous, the more real it becomes and the less intentional it will be.

Our analysis here has not sought to determine which models of computation are realizable in practice (as determined by some interpretation of the Church-Turing thesis). Our position is rather a pluralistic one, at least in the sense that it allows for the existence of various types of CVO, not only digital ones. The future construction of other types of object having their ideal point of reference in a model different from that of the Universal Turing Machine is treated as possible. On the other hand, we believe that the present inquiry has shed light on the question of how many ontological elements virtual objects contain. In particular, we have found that the way of existence of virtual objects goes far beyond the popular opposition of 'real versus fictional'. Since virtual objects are computationally grounded, with the consequence that ideal components of models of computation are realized in them and determine the framework governing their possible and necessary states, ideal beings are also implicated as a realized part of their nature. An important lesson here is that such components of virtual objects can only be grasped if one is willing at the outset to adopt a broad-based ontological perspective: i.e., that of existential pluralism.

Even so, one must also admit—to sound a more guarded note—that virtual objects are ontological bastards. In our ontological analysis, we made use of the ontological tools introduced by Ingarden, yet we were also obliged to note that within the terms of his ontology it is not possible to envisage the mode of being of an entity changing without losing its identity in the process. The process of existential autonomization we have described is a change in the mode of being involved: it is a transition from existential heteronomy to autonomy. Thus, what we would like to think of as being an unbiased study of virtual objects has, it turns out, allowed a certain overall presumption of rigidity within our ontological frameworks (what we might call 'the Parmenidean tendency' within ontology) to be breached. This, we would like to think, constitutes a finding with the potential to significantly influence ontological research, while also confirming the intuition that virtual objects themselves pose an exceptional set of challenges for those engaged in the practice of ontological inquiry. Ingarden's tools have certainly lent valuable support to the analysis of virtual objects, but just like with Wittgenstein's ladder, having completed one's ascent with their help they must be thrown away.

Acknowledgements We thank the two anonymous reviewers for many valuable comments. We would also like to thank Carl Humphries for proofreading this paper.

Author Contribution In preparing this article, BS was responsible for developing the concept of virtual-object ontology, while PW established the computational basis for virtuality. The text is the result of a process of collaborative philosophical reflection seeking to combine the philosophy of computing (PS) with phenomenological ontology (BS).

Data Availability Data sharing is not applicable to this article as no new data were created or analyzed in this study.

Declarations

Ethics Approval and Consent to Participate These philosophical studies do not require ethical approval.

Consent for Publication This article did not require any consent to publish.

Competing Interests The authors declare no competing interests.

References

Bojarski, M., Del Testa, D., Dworakowski, D., et al. (2016). End to end learning for self-driving cars, arXiv:1604.07316

de Castro, L. N. (2007). Fundamentals of natural computing: An overview. *Physics of Life Reviews, 4*(1), 1–36.

Chalmers, D. J. (2017). The Virtual and the Real. *Disputatio, 9*(46), 309–352. https://doi.org/10.1515/disp-2017-0009

Costa, J. F., & Graça, D. (2003). Analog computers and recursive functions over the reals. *Journal of Complexity, 5*(19), 644–664.

Deutsch, D. (1985). Quantum Theory, the Church-Turing Principle and the Universal Quantum Computer, *Proc. Roy. Soc. Lond, A, 400*, 97–117.

Harel, D. (1987). *Algorithmics: The Spirit of Computing*. Addison-Wesley.

Hartmanis, J. (1995). On Computational Complexity and the Nature of Computer Science. *ACM Computing Surveys, 27*(1), 7–16.

Heim, M. (1993). *The Metaphysics of Virtual Reality*. Oxford University Press.

Hogarth, M. (1994). Non-Turing computers and non-Turing computability. *PSA, 1*, 126–138.

Ingarden, R. (1973). *The Literary Work of Art*, transl. by George G. Grabowicz, Evanston, Illinois: Northwestern University Press.

Ingarden, R. (2013). *The Controversy over the Existence of the World*, vol. I, transl. and annotated by Arthur Szylewicz. Frankfurt am Main: Peter Lang.

Ingarden, R. (2016). *The Controversy over the Existence of the World*, vol. II, transl. and annotated by Arthur Szylewicz. Frankfurt am Main: Peter Lang.

Kari, L., & Rozenberg, G. (2008). The many facets of natural computing. *Communications of the ACM, 10*(51), 72–83.

Laas, O. (2015). Contemporary philosophical theories of virtuality Techné: *Research in Philosophy and Technology, 19*(3), 314–357. https://doi.org/10.5840/techne2015121441

MacLennan, B. J. (2004). Natural computation and non-Turing models of computation. *Theoretical Computer Science, 317*, 115–145.

Michalewicz, Z. (1992). *Genetic Algorithms + Data Structures = Evolution Programs*. Springer Verlag.

Polak, P. (2017). Czy wszystko wykonuje obliczenia? Wybrane filozoficzne implikacje pankomputacjonistycznej interpretacji koncepcji obliczeń naturalnych. *Studia Metodologiczne, 38*, 37–54.

Primiero, G. (2016). Information in the Philosophy of Computer Science. In L. Floridi (Ed.), *The Routledge Handbook of Philosophy of Information* (pp. 90–106). Routledge.

Ord, T. (2006). The Many Forms of Hypercomputation. *Applied Mathematics and Computation, 178*, 143–153.

Piwowarczyk, M. (2020). Roman Ingarden's early theory of the object, in W. Płotka & P. Eldridge (eds.), Early phenomenology in central and Eastern Europe. Contributions to phenomenology (In cooperation with the *Center for Advanced Research in Phenomenology*), vol. *113*, (pp. 111–126). Springer. https://doi.org/10.1007/978-3-030-39623-7_7

Pour-EL, M. B. (1974). Abstract computability and its relations to the general purpose analog computer. *Transactions of the American Mathematical Society, 1974*(199), 1–28.

Rozenberg, G., Back, T., & Kok, J.N. (Eds.) (2012). *Handbook of Natural Computing*, Berlin, Heidelberg.

Shagrir, O. (2004). Super-tasks, accelerating turing machines and uncomputability. *Theoretical Computer Science, 317*, 105–114.

Shannon, C. (1941). Mathematical theory of the differential analyzer, *J. Math. Phys, MIT, 20*, 337–354.

Smart, P. (2022). Minds in the metaverse: Extended cognition meets mixed reality. *Philos. Technol., 35*, 87. https://doi.org/10.1007/s13347-022-00580-w

Siegelmann, H. T. (1999). *Neural networks and analog computation: Beyond the Turing limit*. Birkhauser.

Skowron, B. (2020). Virtual Objects: Becoming Real. *Horizon. Studies in Phenomenology*, 9, 619–639. https://doi.org/10.21638/2226-5260-2020-9-2-619-639

Stacewicz, P. (2019). Wirtualność w perspektywie obliczeniowej. In Stacewicz, P. & Skowron, B. (Eds.), *Przedmioty wirtualne*, (pp. 36–45). Oficyna Wydawnicza Politechniki Warszawskiej.

Stacewicz, P. (2020). Analogicity in computer science. Methodological analysis. *Studies in Logic, Grammar and Rhetoric*, *63*(1), 69–86.

Steuer, J. (1992). Defining virtual reality: Dimensions determining telepresence. *Journal of Communication, 22*(4), 73–93.

Thomasson, A. (2017). Roman Ingarden. The stanford encyclopedia of philosophy (Fall 2017 edition), Edward N. Zalta (Ed.), https://plato.stanford.edu/archives/fall2017/entries/ingarden/

Turing, A. M. (1936). On Computable Numbers, with an Application to the *Entscheidungsproblem*. *Proceedings of the London Mathematical Society, 42*, 230–265.

Turner, R. (2018), *Computational artifacts. Towards a philosophy of computer science*, Berlin, Springer.

Turner, C. (2022). HoloFoldit and hologrammatically extended cognition. *Philos. Technol., 35*, 106. https://doi.org/10.1007/s13347-022-00596-2

Turner, R., Angius, N., & Primiero, G. (2019). The philosophy of computer science. The stanford encyclopedia of philosophy (Spring 2019 edition), Edward N. Zalta (Ed.), https://plato.stanford.edu/archives/spr2019/entries/computer-science/

Zenil, H. (Ed.). (2013). *A computable universe: Understanding and exploring nature as computation.* World Scientific.