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Turning Away from an Anthropocentric View on Robotics

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Abstract. The field of artificial intelligence and robotics has long adapted an anthropocentric view, putting the intelligence structures of humans as the guiding requirements for developing artificial intelligence. This paper use observations of a robotic lawnmower to demonstrate how we can apply Jakob von Uexküll's Umwelt theory to describe robots and robot behavior to further our understanding of the behavior of different kinds robots.

Keywords. Human-robot interaction, robots, Umwelt theory, phenomenology, artificial intelligence

1. Introduction

From the start of artificial intelligence and through to today the milestones for judging whether we have created something intelligent has been tied to human intelligence and human activities, such as language and games. Nietzsche wrote that there once was a star on which "clever animals invented knowledge", but that only we, the owners of the human intellect "gives it such importance, as if the world pivoted around it" [1]. In light of this observation, it is not all that strange for humans to set the criteria to human standards of what we consider traits of higher intelligence, after all we project our own world views into most things [2, 3]. At first glance, it would seem apparent that we should create AI in our perceptual image; after all, many are created with the intent of assisting us.

In the 1980s Moravec [4] introduced the notion that robotics and artificial intelligence could learn from nature and evolution. He points out how problem-solving AI's easily mimic competent adult humans, yet robotic systems rarely achieved the bodily coordination of a four-year-old child. This, he argues, is because there is a qualitative difference between the relative performances of eye-hand systems and the reasoning systems: "Amateur quality high level thinking can be done by an efficiently organized system doing 10^8 instructions/second while average quality perception and action requires 10^{11} instructions/second" [4, p. 220], illustrating that movement and perception requires a lot more processing power than does abstract thinking. In his short essay, Nietzsche further writes that, in nature, the human intellect appears wretched, shadowy and flighty, aimless and arbitrary [1]. This may be a harsh verdict, yet it is necessary to get the message across: *What we consider our best traits of intelligence is ironically not the most intelligent actions we perform in our daily lives*. Nietzsche reminds us of our self-assumed significance, "… if we could communicate with the mosquito, then we would learn that he floats through the air with the same self-importance, feeling within itself

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the flying center of the world" [1, p. 1], and Uexküll can teach us that though we all live under the same sun, the mosquito does not experience the sun as we do.

It has been pointed out by Ziemke and Thill [5] that whatever conception of embodiment we adopt has a significant repercussion for the role that we envision social robots to play in human society. How we view the potential and limitations of human-likeness of robotic embodiment and intentionality, also influence how we view robots' potential role as agents within human society, as social and ethical agents. We argue that robots will be better equipped to assist us if their understanding of the world become more tightly connected to the design of their bodies—concerning their possibilities and limitations for action and perception regarding the environment they will inhabit.

In this paper, we give a thorough introduction of Umwelt theory and a brief examination of what role embodiment and situatedness has in the development of robotics. We then use observations of a robotic lawnmower to discuss how Umwelt theory can be used to describe robots and robot behavior to further our understanding of how a robot's body matter for its interpretation of the surrounding environment.

2. Background

Robots have a radically different motor and perception apparatus from humans. Robot vacuum cleaners and lawnmowers, for instance, carry a larger resemblance towards arthropods, having plastic exoskeletons and moving closely to the ground. For the most part, robots have very restricted sensory abilities, naturally followed by limited action possibilities. Because of the profound bodily differences between humans and robots, we cannot expect similar 'perceptions' of the environment; robots do not sense the world in the same way humans do. By considering the importance the material body has for the perception and experience of the world we can appreciate the fundamental differences in worldly interactions. To do this, the following section look at Jakob von Uexküll's Umwelt theory and related work within robotics that tackles issues of embodiment and situatedness.

2.1. Umwelt Theory

Jakob von Uexküll (1864-1944) was a biologist, who worked in the field of ethology and cybernetics of life, his work forerunning modern biosemiotics. Uexküll saw that each subject has a unique perception of the world from others, even with shared environments. These differences may vary only slightly between conspecifics, but can vary greatly between species. This was named *Umwelt*, often translated to 'the self-centered world' but can directly be translated to 'the surrounding world'.

Uniquely to his work, was not only that he saw each living subject as having a unique world, but also how he managed to express this through Umwelt theory. Sagan [6, p. 20] characterize Uexküll writing as shaman-like when he describes the world of an individual of another species. Most famous is perhaps his example of the tick, where he recounts how the fully developed and copulated female tick will climb onto a branch and stay there (waiting for up to eighteen years!) until a warm-blooded animal passes beneath her:

> The eyeless tick is directed to this watchtower by a general photosensitivity of her skin. The approaching prey is revealed to the blind and deaf highway woman by her sense of smell. The odor of butyric acid, that emanates from the skin glands of all mammals, acts on the tick as a signal to leave her watchtower and hurl herself downwards. [7, p. 321]

Should the tick fail to land on something warm, she must again climb atop her watch-tower, for she missed her prey. If she succeeded, and landed on something warm, she will bite through the skin and eat her last meal, before falling to the ground to lie eggs, and die. This is the life cycle of the tick, made possible by what is essentially the three receptor cues and three effector cues that is her Umwelt.

Animal behavior can be studied and understood through 'functional cycles'. Functional cycles speaks about the relationship between the subject and the object, and the same subject can be connected to the same, or various, objects through several functional cycles [7, p. 324]. The more receptor and effector cues, the more functional cycles are needed to carry out the animals' behavior. To better explain, let us continue with the example of the tick, that according to Uexküll's analysis has three distinct perceptual and effector cues, therefore it also has three functional cycles. First, that of all perceptual cues the tick could have had of a mammalian presence, the one thing a tick can smell is also the only molecule present in *every* mammal. Next, cue is the temperature of its landing spot telling informing her whether she hit her target or not. Lastly, she has no sense of taste, but is also sensitive to the temperature of the liquid she starts to drink. If it has the correct temperature, she will drink it no matter what. A functional cycle can thus be viewed as an Uexküllian analysis of behavior.

Uexküll's conception of 'functional tones' and 'functional cycles' are central to his theory of meaning. A functional tone is akin to James Gibson's *affordance* [8]: An object can have different *tones* according to the *mood* of the animal. The tones are important because they are altered by the perceptions of the subject in regards to what a specific object is, namely what the object is *to the animal in its current mood*, which will in turn affect its actions towards it [7]. As a way of understanding animal behavior, functional cycles can show how an animal is fitted into the world. Eloquently described by Uexküll, "out of the vast world which surrounds the tick, three stimuli shine forth from the dark like beacons and serve unerringly to her goal" [7, p. 325]. It is the poverty of her world that ensures her success in surviving and reproducing, because security is more important than wealth [7].

What the subject perceives become their perceptual world (*Merkwelt*), and the subject's actions become their effector world (*Wirkwelt*). Together these worlds, Merkwelt and Wirkwelt, form a closed unit, the *Umwelt*, which contains absolutely everything a specific subject can act on and perceive. Amongst the various descriptions, Uexküll illustrates Umwelt as a garment or cloak that wraps itself around the subject, and being the center, the subject can never leave it. In other words, everything that is touched upon by your sensory apparatus and the changes you make (which must naturally be within this space) is your Umwelt. Each sensory organ separates into distinct sensory spheres: "For man, all distant objects are sight-objects only, when they come closer they become hearing-objects, then smell-objects and finally touch-objects as well. Finally, objects can be taken into the mouth and be made taste-objects" [9, p. 57].

A central theme in Uexküll's writing is the human attitude towards all other organisms, caused by an anthropocentric worldview. Because humans can communicate accurately, we have long been discussing the world around us with each other, and found that the objects in our environment are the same. According to Uexküll, this is a falsehood that arose because—if we do not consider individuals who are born with, or develop, sensory disabilities—the sensory spheres of human individuals are the same, and the human Umwelten and the objects within them are therefore very similar to each other [9]. Though I may meet me-things, and you meet you-things, these variations are small. However, us humans can only communicate accurately between conspecifics, and thus, we cannot ask animals how the objects appear to them in their world. We can only present them with an object and observe their reaction. Thus, animals have according to Uexküll been viewed more like “aimlessly running machines” that experienced some random effects and in turn sent out random responses, rather than subjects who *experience*, like do humans.

Uexküll “theorized about organism-environment interaction in terms of subjective perceptual and effector worlds, and thus contradicted anthropomorphic as well as purely mechanistic explanations” [10, p. 704], and suggested a “non-anthropomorphic psychology in which subjectivity acts as an integrative mechanism for agent-environment coherence” [10, p. 705]: Perceptions, communications and purposeful behaviors are not limited to human beings, but a part of nature’s purpose [6]. And by viewing animals as machines, they are by extension viewed as objects, instead of individuals acting according to their subjectivity. Yet another central aspect to Uexküll’s thinking is that interactions between living things are unlike those between objects, as objects interact with each other only according to physical laws. To “find out about the Laws of life” Uexküll writes, “it is thus musical and not mechanical laws that we need to study” [11, p. 67]. Though the use of a ‘theory of the music of life’, comparing the display of nature to that of a musical piece, is somewhat curious, there is a merit to this view: Through this metaphor Umwelt is easier to understand, whether you buy into Nature’s plan or not. Especially how different a simple and a complex Umwelt becomes much clearer. It is one of the ways Uexküll’s shaman-like abilities are articulated.

First, he explains how we can start to understand simple examples, such as how a beginner learns to play etudes on the piano with one finger: “As only a few keys of the whole keyboard are used in the simple etude, the simple Umwelten contain only a few perceptual cues” [11, p. 69]. Knowing this enables us to start exploring richer Umwelten, such as that of the honeybee, illustrated in Figure 1. “But even here the richness in forms and colors of a flowering meadow, that is visible to the human eye, is very much simplified” [11, p. 69]: The honeybee can only perceive two visual cues for open and closed forms, enough to distinguish between open flowers and closed buds. It can see only four colors, though one of them are not visible to humans, ultraviolet, blue, green, and yellow. The only sense that has a considerable richer sphere than humans is its sense of smell.

Figure 1. A meadow in a human Umwelt (left) and the same meadow in a bee Umwelt (right) [7, p. 351].

Further, Uexküll explains that by knowing the theme of the music (*Lebensmusik*) that is 'played' by a given animal's Umwelt, one can—to some extent—predict the number of perceptual cues that Umwelt will have. For instance, the Lebensmusik of the bee is the collection of nectar and pollen, which explains that the form, colors, smell, and taste of flowers become their perceptions. Because of humans' and bee's very different Lebensmusik, the meadow of the honeybee is very different from the human meadow: "It is a honeybee composition made up of bee notes and is much easier to comprehend than our human Umwelt composition" [11, p. 70].

2.2. Related Work

Both existing life and records of evolution gives us an insight into how difficult it is to create intelligence from nothing. In the question of general intelligence, Moravec [4] pulls forward mobility as the main characteristic for when such a feature would be evolutionary preferable. A plant cannot leave its birthplace to locate nutrition, mates for reproduction, or avoid being eaten. But never moving also means that the challenges one faces will be similar in character and can be overcome through specialized mechanisms, thus need for sudden adaption is a rarity. Indeed, plants live their lives as experts in their particular patch of land. For the rootless animal on the other hand, the nature of mobility favors not in-depth expertise but a more general adaptability as the main defense mechanisms against the large variety of challenges encountered through this lifestyle. Moravec concludes: "*A mobile way of life favors general solutions that tend toward intelligence, while non-motion favors deep specializations*" [4, p. 221]. So, just as how general intelligence was created by nature, he holds that the development of a responsive *mobile* entity is the best way of approaching the problem of creating an artificial general intelligence.

In the 1990's, Brooks [12] used this as a basis for his robotics development attempting to develop robots of insect-level intelligence. Focusing on the role of the body in the development of artificial intelligence, he established two cornerstones of this new approach to AI: situatedness and embodiment. Only embodied agents can deal with the real world, and being situated within it provides continuity to the agents. Intelligence itself cannot be separated from environmental interactions and identifying any seat of intelligence as it "can only be determined by the total behavior of the system and how that behavior appears in relation to the environment" [12, p. 16]. Yet, as Brooks also imply, physical grounding does not equal understanding, and intelligence arise within the eye of the observer. Through the Chinese Room Argument, Searle [13] explains how flawless manipulation of formal symbols does not imply an actual understanding of the *meaning* of the symbols that are handled—what they represent in the real world. This process lies in the mind of the observer and programmer. Our mistake is to believe that just because we are able attribute the ability to understand *to* the system, it will. In the same manner no one assumes that a computer simulation of a fire alarm will burn down the neighborhood, Searle raise the question of how anyone would suppose that a computer simulation can understand anything [13, p. 423].

Critiques of traditional AI has enabled research within AI to shift from pure software to a fusion of software and hardware, and there is currently a large focus on physically situating intelligence in the environment through robotics. The importance of the body is now recognized. However, Ziemke [14] points out, many researchers within embodied AI believe that embodiment and artificial intelligence is a straightforward matter, that traditional AI computer programs are disembodied, and robots are embodied. At first glance, it can appear that giving an artificial intelligence a robotic body, situating it in the world through physical interaction within the environment, thus grounding the symbols, would lead to the understanding of them. But this view leapfrogs the core issue presented by Searle: It does not matter what the actual nature of the input and output are—which in case of the robot would come from sensors and motors—the formal symbol handler that is the man in the Chinese Room does still not understand Chinese.

Here springs forth the currently unanswerable question of whether true intentionality, autonomy, and thus true understanding can be artificially created without a 'natural' possession of ontogeny. The only thing we can know for sure is that this is not the case for any contemporary robots [15]. Ziemke and Sharkey [10] argue that Uexküll's theory of meaning can deepen the understanding of using signs and representations in living beings, thus clarifying and assessing both possibilities and limits of autonomy and semiosis in artificial organisms [10, p. 703]. They discuss different kinds of self-organizing, and the role this technique plays in creating autonomous machines, leading to interactions where the symbols and representations are not tied to any human experience. The self-organizing process itself "… determine which of the object in the environment become carriers of meaning, and what exactly their meaning is to the agent" [10, p. 726].

Language muddles our intentions whenever we discuss robots and terms such as embodiment, situatedness and agency [15]. The same can be said for how the term *perceive* or otherwise words associated with subjective experience are being used in this paper. While this paper urges to turn away from anthropocentrism, the irony we can never escape is that our language is based on the human experience. Because our language lack the words to describe the artificial counterparts of these processes, any words that correlate to sensory functions of biological systems are used purely metaphorical. A short example is a statement such as "using Umwelt theory to see things from the robot's perspective". The robot does not *see* anything even if it is equipped with a camera, because light detection is not a form of vision: "Vision is the capacity to perceive and classify objects using light, or seeing" [16, p. 269]. To put it like Searle, no one assumes that a camera can *make sense* of the light it captures. While we might know this, it is hard to even conceptualize and especially talk about without being confused or confusing others. This paper does not argue that robots, per today, are subjects, or that they perceive in any biological sense of the word, or that robots have a perspective in like living organisms have. However, because the human conception of robots influences their creation and adaption, the next section intends scrutinize the sensory world of the robot by applying Umwelt theory to the perceptual world of a contemporary situated and embodied robot. And while no human cannot possibly imagine what the world is like for a robot, we can try by using what we know about a robot's effectors and sensor—the components that make up its body.

3. Discussion

According to Umwelt theory, every animal is surrounded by different things [11, pp. 66–7]: A dog is surrounded by dog things, humans are surrounded by human-things, and a tick is surrounded by tick-things. When applying Umwelt theory to robotics, '*what are the robot-things that surrounds the robot?*' spring to mind as the immediate question. But this question is too open and cannot lead us to any good answer. Uexküll has shown us that each animal species has their own way of being in the world, and that we cannot make a simple separation between the worlds of humans and animals. Similarly to how each animal species has a unique Umwelt, so will each species of robots [17 (though Brooks use only the term *Merkwelt*)], and thus also robots must be viewed in light of this. This correctly indicate that the things that surrounds lawnmower robots differ from the things that surround vacuum cleaning robots. The differences between the things in the Umwelten of these two kinds of robots are obvious to spot because their respective environments of operating do not overlap. However, this obvious environmental separation and its inherently different furniture limit the reach of the question. The core of the matter sits deeper. While the vacuum cleaning robot meets things like kitchen tables and chairs, and the lawnmower meet garden tables and chairs, whether the specific chairs and tables belong in the kitchen or in the garden is a human-specific categorization of these artefacts: Their label has emerged from the human Umwelt and is irrelevant to the robot. More to the point will be to compare how the different robot species encounter the same artefact. How a robot is made will determine what the things within its environment is to it.

It would be more adequate to compare a human and a specific robots meeting with the same, overlapping environment. For this purpose, we choose a lawnmower robot we have made some observations about, named Roberto by its owners. By doing this, we can ask, '*what are the things that surround the lawnmower robot?*' without obscuring the answer. Yet, answering is neither straightforward nor easy. To discuss toward an answer, we need to make a quick scheme of Roberto's sensory spheres. In order not to destroy itself, flowers, or otherwise cutting objects that are not lawn, it is equipped with a boundary wire. To humans, this fence appears as a closed-circuit cable laid around the edges of the lawn from the charging station. Leading from the charging station and outwards in a straight line is a cable that make out the robot's guide wire, which the robot uses to find its way to and from its charging station. When working, the robot roams freely and blindly in a randomized, irregular pattern within the boundary wire, and does not stop until it meets the fence, or unless its crash-sensor is triggered, informing it about an obstacle. If it is lifted, the knives will immediately stop spinning, and will not start again until the robot is safely back on the ground. About itself, Roberto knows when it is low on power, and when it is fully charged. It knows the time and can have a schedule for when it should be working and when it should not.

These are the sensory spheres of the robot lawnmower of Roberto's brand and model. Knowing these, we can start to theorize about the objects in this lawnmower's Umwelt. Though the guide wire is always physically present, the robot will ignore it unless it is low on power or the time tells it that work is done for the day and in need of returning to its charging station. It will also use it on the way back when done charging or starting work. Thus, there is a guide wire-object only when the robot is on its way to or from the charging station. Similarly, the robot is not aware of the boundary wire when working and roaming. Only when it approaches the boundary wire does there appear a boundary wire-object in Roberto's Umwelt, and it can cross the boundary with a few centimeters before turning around. This make the perceptual cue of the boundary wire different from that of a crash. Whenever the robot meets an obstacle, it must physically crash into it in order to detect it. Once it does, it stops immediately, turns, and goes in another direction. Roberto does not plan a trajectory to avoid objects because to it, there are no objects: In a way, we can then say that every object in the lawnmower's Umwelt is a crash-object, and unless it crashes, the Umwelt is devoid of any objects. Roberto's sensory spheres are confined to the boundaries of its robotic body. The Umwelt of the robot lawnmower is simple; until it crashes, finds itself close to its boundaries, or is low on power, it works in complete isolation from the environment. We have tried to illustrate this in Figure 2.

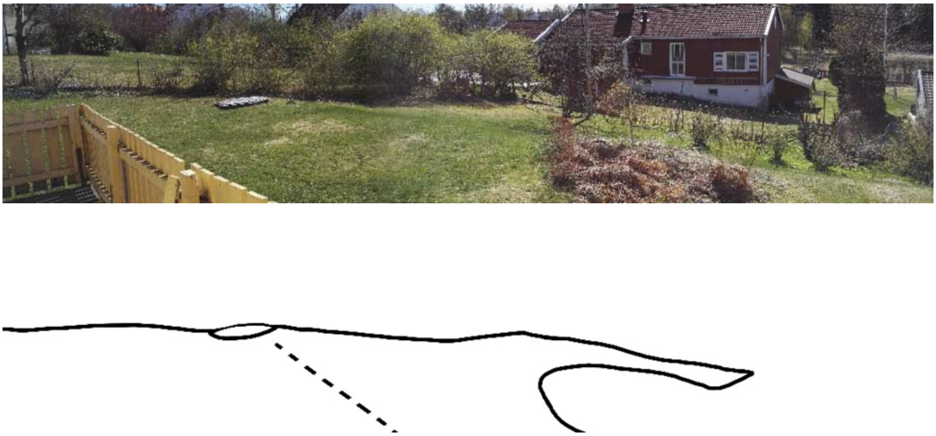

Figure 2. A garden according to the human Umwelt (top), the same garden according to a Roberto's Umwelt (bottom) where the thin line represents the boundary wire and the dotted line the guide wire.

About the simple Umwelten Uexküll say: "In the complete silence of the Umwelt of the deaf the appearance of the only perceivable tone must have the overwhelming effect as the only smell in an odorless space" [11, p. 69]. Similarly, we can imagine how overwhelming an impact must be in the completely empty world of the lawnmower robot. To avoid destroying things or hurting anyone the only effector mark in the functional cycle catalyzed by the perceptual cue of a crash-object is the robot stopping dead in its tracks, and turning away. For the tick and lawnmower alike, security is more important than wealth. The rich world around the tick is turned into three receptor cues and three effector marks [7, p. 325], and above we have described how the rich world around the robot is turned into five perceptual cues, and the more unaddressed effector marks of mowed grass, stopping, turning, and irregularly moving across the lawn. Indeed, just as the poverty of the tick's world guarantees the unfailing certainty of its actions, one would draw the conclusion that the poverty of the robot's world ensures it will not become stuck, destroy things, or hurt anyone.

Uexküll states the first principle of Umwelt theory to be that "all animals, from the simplest to the most complex, are fitted into their unique worlds with *equal* completeness" [7, p. 324, emphasis added]. Yet, the following observations show how the functional cycles of a lawnmower robot such as Roberto is not fitted into its world with the equal completeness that animals are fitted into their natural environments. Unless Roberto's crash sensor is triggered and the world is devoid of anything, the robot will continue to mow, even if it runs over objects on the ground. This can cause trouble for the robot, as have been observed in the case of Roberto. During late summer, apples from the garden's apple tree fall to the ground. To Roberto, these apples do not exist because they cannot be detected by its sensors. The robot thus runs over them, the knives become stuck, and Roberto can no longer move and turns off. To get out of this situation and back to work, the lawnmower is in need of human assistance. Further, the garden has a small hill that is too steep for the robot on rainy days, or when there is a lot of morning dew. If Roberto attempt to climb this small hill when the grass is wet, the robotic effectors are not powerful enough, and the lawnmower becomes stuck. Again, only human assistance can get the lawnmower back to work.

These observations make clear how robots sometimes fail to perform their tasks, requiring human assistance to help them out. Uexküll states: “The flower stem itself, as a part of the living plant, consists of components connected to one another according to a plan; they represent a more thoroughly formed mechanism than any man-made machine” [18, p. 143]. He here says that machines act according to plans, whereas living organisms are acting plans. Again, while Uexküll’s obsession with Nature’s plan can be considered excessive and outdated, the core of this statement is reflected in the robotic design discussed above. The functional cycles of animals have evolved with the body of the animal and the Umwelt this body give in relation to the environment and other living creatures. Instead of being created by themselves, to serve themselves and their own survival, robots are created by humans to serve a human need. Indeed, robots are not subjects, but they do have bodies. In the Uexküllian sense, having a body enables the entity to pick up perceptual cues and leave effector marks; to exhibit behaviors and performing them through physical actions in the real world. While having a physical manifestation and functional cycles does not automatically lead to any true understanding of the environmental signs being handled, they should be allowed freedom from a human designed and pre-decided guide for ‘how to understand the world’. By analyzing robotic behavior through its functional cycles, we begin to better understand how their radically different their sensory world is from our own. This insight brings us one step closer to fully fitting any given robot’s Umwelt to its environment. Moravec correctly observed that evolution has had a long time to bring forward its designs [4], and human-created machines are—if not in its infancy—early days still.

4. Conclusion

The Umwelten of many contemporary robots are simple because they have a simple sensory-motoric apparatus. It differs vastly from the well-articulated and complex human Umwelt, making it useless to have the robot classify objects according to human categories. Ziemke and Sharkey asks “what could a conversation about the objects of human experience (like tables, chairs, etc.) possibly mean to a computer system completely lacking this type of experience” [7, p. 727]. The robot will not find the same objects within the environment as humans do, and different kinds of robots will not even find the same objects within the environment as the other. Recognizing that each bodily construct creates a unique Umwelt, vastly different from both our own and each other’s, can merit the design and development of robots. By using Uexküll’s Umwelt theory, we can step inside the world of a contemporary robot, where it is possible to analyze how objects within its working environment might appear to it and how this affects is behavior.

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