

Research Article

Characterisation of Intelligent Autonomous Agents Inspired by Biological Theory in Cognitive Environment

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The paper investigates a naturally motivated meaning of wise shrewd self-ruling specialists of humans. Knowledge is identified with whether the conduct of a framework adds to its self-upkeep. Conduct turns out to be clearer (or adapts to more biological issue factors) when it is able to make and utilize portrayals. The thought of portrayal ought not to be confined to formal articulations with neuro hypothetical semantics. The element at different degrees of canny frameworks assumes a fundamental part in shaping portrayals. The paper investigates an organically roused meaning of shrewd self-ruling specialists of humans. Insight is identified with whether the conduct of a framework adds to its self-upkeep. Conduct turns out to be keener when it is proficient to make and utilize portrayals. The idea of portrayal also focused on formal articulations with sentimental hypothetical semantics.

1. Introduction

A specialist is self-governing in case it can adapt to every one of the results of its activities to which it is oppressed while staying suitable as an errand-accomplishing specialist on the planet it works in. For a specific specialist acting to accomplish some specific undertaking or errands in some specific climate, its self-sufficiency will be limited: it cannot adapt to all potential results of its activities. Self-rule is consequently an issue of degree [1]. It is, in any case, a vital essential for keen conduct: the pretty much independent a specialist, the pretty much it is potential for keen conduct. The inquiries of how self-sufficient a specialist is, the way it acts cleverly, and what the limits are on its wise conduct, are in this way all intently related. In this way, see the examination of self-governing conduct by building robots as appropriately a piece of artificial intelligence. In computer-based intelligence, as in the connected disciplines of intellectual brain science, robotics, ethology, and neuroscience, it is an all-around dug in a doctrine that insightful frameworks

are data handling frameworks: that the climate of a cleverly acting specialist can be uniquely described in the entirety of its fundamental detail as a universe of data and that the specialist's collaboration with this climate is to be appropriately perceived as including the getting and handling (normally in some intricate method) of this data to create fitting choices about additional activities. In man-made intelligence, the data preparing perspective on a specialist is typified in the physical symbol system of a shrewd specialist. As indicated by this old style sort of AI, image handling is the best approach to do the vital data preparing and how to cause the educated, normal activity choosing conduct of an astute (independent) specialist. Old style as fundamental adversary today connects and rejects unequivocal image control as the reason for canny conduct yet still exemplifies the idea of data handling: here, it is the aggregate conduct of enormous quantities of straightforward computational components that check, as opposed to express images and their control. In intellectual brain research, the idea of data and its inside portrayal and application was offered as the shared

belief between its different establishing disciplines and presently plays an unchallenged crucial job in the entirety of its discussion and portrayals.

2. Publically Intellectual Robots

The term socially insightful specialists is used to describe organic or counterfeit specialists which show components of human style social association and conduct. An examination bearing which focused on the specific job of social interaction dynamics in bootstrapping the improvement of social cognizance is presented. This examination in mechanical technology depends on the assumption that to contemplate the intellectual development of robots, we need to think about the robot in the public eye. Our work on socially clever robots shows the accompanying correspondences to Vygotsky's way to deal with children's cognitive turn of events: (1) communication for correspondence. We study an automated language for the main role of correspondence; in a later advance, we research how the specialists may utilize their relational abilities. (2) Learning in a social setting. We examine learning by educating [2]. In our trials, the student utilizing an imitative after the system is in a real sense directed by the educator through the climate. This is more identified with Vygotsky's "orchestrating encounters" thought as opposed to pedantic teaching. The educator robot in our investigation does not specify what ought to be realized; the images which are imparted are according to the student's perspective dealt with like some other perceptual info. (3) Internalization. The student learns based on its own sensory-engine encounters; the student's own movement is (as both Piaget and Vygotsky contend) at the focal point of the learning interaction. As images are discovered that portray certain circumstances (described by sensory-engine experience), they structure a premise to be utilized in successions, for example, to create a succession of activities, or a sentence. (4) Shared agreement. The student robot's acquisition of a language is the aftereffect of rehashed social connection until the student specialist has successfully "comprehended" the word, which implies that it had the option to utilize its acquainted memory to recreate the word in a comparative setting. A student can turn into an instructor with the goal that a mutual perspective can create in a gathering of specialists. Various cognitive models, processes, and their effect on AA's architecture is given in Table 1.

3. Statistics Dispensation

Slugs and indoor regulators are generally utilized (basic) models found in numerous representations. Those people having intricate adaptations of data handling frameworks are underestimated [3]. In any case, what is data? Regardless of its practically all-inclusive work in describing self-sufficient frameworks, and wise frameworks as a general rule, there is no reasonable far and wide arrangement about what data is and what data handling implies; the idea has been determinedly broken down and reanalyzed. The time and exertion consumed on these investigations should certainly rank as perhaps the most unbeneficial interests in current logical his-

tory, as there has been no benefit; yet in addition, the actual cash has been spoiled to uselessness. This has not forestalled its far-reaching and unchallenged use in portraying the activities of natural and counterfeit-independent frameworks in deliberation from their implementation subtleties and specifics. In the part cited above, Rosen proceeds to address whether the idea of data has any genuine logical importance. He inquires as to whether it probably will not be a transitory human catalyst which only mirrors the youthfulness of our study (of savvy frameworks) and that maybe it ought to be supplanted at the soonest conceivable chance by more thorough ideas like power, energy, and potential.

4. Regular Evidence Theory

Data hypothesis, basically as indicated by Shannon, can be introduced similar to the investigation of one hypothesis, the alleged central hypothesis of data hypothesis, which expresses that it is feasible to communicate data through a loud channel at any rate not exactly the channel limit with a self-assertively little likelihood of a mistake. The sort of framework it is in this manner worried about is displayed in Figure 1 and will be known as a correspondence framework.

In this kind of framework, data is imparted between two segments by the sending of messages through a channel which might be liable to remotely incited calmer, along these lines bringing about some debasement in the nature of the messages being conveyed [4]. As per the data hypothesis, by choosing proper encodings (and decoding's), the measure of corruption can be made self-assertively little at the expense of lessening the rate at which messages, and along these lines data, can be effectively conveyed. A significant aftereffect of the data hypothesis is that to accomplish the discretionarily high unwavering quality of correspondence, it is not important to decrease the transmission rate to nothing, however just to a number called the channel limit. The other significant idea presented by the data hypothesis is that of the data content of the message, now and then likewise called the determination content. This is not a proportion of the "signifying" of the message, yet a proportion of the vulnerability lessening impact on the condition of the message recipient about the condition of the sender. For instance, assume that an arbitrary variable X in the message source (see Figure 1) can take the qualities 1, 2, 3, 4, and 5, with equivalent likelihood. We would then be able to ask how much data is imparted by a message shipped off the collector which expresses that $1 \leq X \leq 2$, likelihood (1/2) of being right. As such, the collector has less vulnerability about the worth of X having gotten the message. We can see from this basic model that for data transmission to be conceivable, the facts must confirm that there is a limited number of states about which messages will be sent and a limited (however, perhaps unique number) of states in the collector which are to be set in a correspondence connection to those of the sender, which it should likewise think about. On the off chance that, in our model, the message collector did not definitely realize that the worth of X could just take one of the qualities 1, 2, 3, 4, and 5, then, at that point, the

TABLE 1: Cognitive processes and effect on AA’s architecture.

Model	Cognitive processes	Effect on AA’s architecture
Alma	Decision-making, motivation, behaviour expression generation, and dialogue generation	Analysis of sentence lengths and facial expressions, bias in cognitive processes such as decision-making, and generation of verbal and nonverbal expressions
Cathexis	Memory systems, behaviour systems, perceptual, and motor processes	Decision support in virtual and physical agents aimed at goals and personality management
Flame	Memory systems, decision-making, learning, and adaptation	Decision support in virtual human beings developed (educational purposes)
EMA	Support for cognitive, perceptive, and motor operators	Generation of voice expression facial and nonverbal

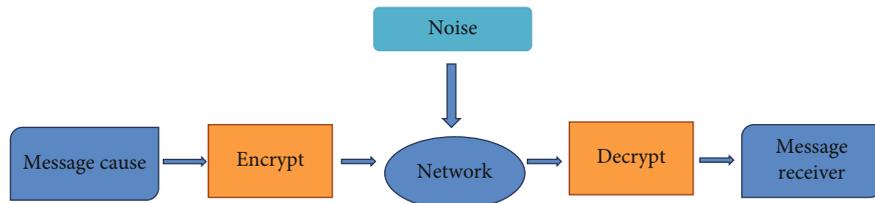


FIGURE 1: Framework of evidence theory.

communicated message would not have the vulnerability diminishing impact depicted previously. At the end of the day, the message would not have any data content for the collector. Along these lines, messages that cannot be decoded into vulnerability lessening states in the beneficiary about the condition of the message source contain no data.

Overall, then, at that point, the data content measures the factual suddenness of the states (or occasions) being referred to. The point-by-point nature of the state or states included is not significant, besides as it may influence their earlier probabilities.

5. Abstracted Information Processing

The sort of data conveying framework depicted above is not the sort of framework generally visualized when we see frameworks portrayed as data handling frameworks. In AI and the intellectual sciences, as a rule, it is assumed that what is of interest is the manner by which the data got by a framework is accordingly prepared into choices about additional activities, for instance. This expresses that an actual image framework is vital and adequate for general wise activity. In spite of the fact that is not intended to propose that there is no requirement for proper tactile engine associations of the specialists to its reality, to help the assignment and translation of the images, it does fundamentally underplay very what this must include.

All in all, the investigation of such data preparing frameworks is disconnected away from the subtleties of how data is imparted to it, or how it comes to have the data it measures [5]. A result of this reflection, and one which has practiced different individuals in AI, is the topic of where does the significance of the data being handled by a specialist come from, this, far beyond the topic of how the messages are directed to it by its sensors about its current circum-

stance having vulnerability decreasing substance for it. For instance, endeavoured to manage this inquiry by advancing the possibility that the semantic substance of an educational state inside a specialist—its appropriate propositional understanding—is fixed by the progression of data into the framework makes the framework be in that state. For this, an advancement of standard data hypothesis which shows how specialist’s employment state can have a particular propositional content than addressing a proportion of the specialist’s vulnerability about some other framework express that it has fetched the data about.

A diverse endeavour to clarify how the inward states prepared by a specialist can have significance is introduced; also, an unmistakable investigation of the connection among importance and portrayal is introduced. This worry about the beginning of significance, its association with data, and how keen conduct can be achieved by the calculation-based plans of image preparing or fake neural organizations has clouded any worry for where this data comes from in any case. As Rosen proposes, data is whatever is or can be a response to an inquiry, since , things in real-time is uncertain. Or then again, in the expressions, “where is the sender of the message?”. This oddity is tackled by bringing up that it is the feelings of a creature that “give the data to life, which relies on the upkeep of request.” For him, “discernment is the dynamic quest for the arranged highlights that we call ‘data.’” What the faculties look for is given by the necessities of the creature, which characterize the inquiries that need replying. The highlights chosen by the faculties in this manner become the data sent by the organic entity’s current circumstance, and got by it detects, in response to these inquiries.

However, created by a neuroscientist, I think this thought of a specialist’s current circumstance sending messages containing the responses to questions raised by its continuous necessities catches very well the position that

underlies every one of the different sorts of data handling portrayals of independent specialists. It upholds the thought suggested by numerous individuals of the theoretical data handling approaches that specialists by one way or another peruse the messages offered by its current circumstance, for a decent delegate illustration of this sort of preoccupied data preparing the way to deal with independent specialists.

This assumed data-based connection between a self-sufficient specialist and its current circumstance is portrayed in Figure 2. Specialists get the data they measure by circumventing perusing the marks on the items and conditions of the world. The issue of how a specialist's sensors are to peruse this load of names is normally thought to be an issue for the architects, and not one which encroaches on the issue of how the data so gotten is to cycle to deliver wise-independent conduct. For an investigation of this traditional methodology in shrewd mechanical technology, a recognizable proof of a portion of the issues emerges.

6. Information Handling and Reckoning

The inquiry that this overall utilization covers up is when advanced (computational) frameworks are preparing framework by considering the advanced sign framework. This mirrors the basically intelligent or formal nature of data preparing as it is by and large comprehended. This comparison of data handling with advanced calculation is more a verifiable improvement than it is an acknowledgment of a central relationship. This can be seen from the reality that we, as a rule, call simple framework signal handling frameworks, not data handling frameworks.

However [6], with the pattern to supplant more established simple advancements with more present-day computerized advances, we do not begin calling such frameworks data handling frameworks. Minimal disk players are not called data handling frameworks, while the more seasoned, record playing frameworks stay assigned preparing frameworks. The inquiry that this overall utilization covers up is that when advanced (computational) frameworks are preparing framework, and then, an advanced sign-preparing framework shall be involved. The incongruity of this is that record playing and compact disk playing frameworks can a lot all the more effectively be related to the correspondence frameworks, which are the subject of data hypothesis, and can sort frameworks commonly assembled and explored in AI and related disciplines. What we can recognize from the partner of calculation and data preparing is the basically syntactic nature of data; what is more, it is preparing. It is a syntactic matter ward on the structure; what is more, it is an association of intelligent activities, not on the actual conduct of the implementation gadgets utilized, as simple sign preparing is. Where the "signifying" of this data preparation comes from is, as we have said, an additional inquiry. We will return to this angle last mentioned.

7. Agent Classifications

The different definitions examined above include a large group of properties of a specialist. Having chosen a substan-

tially less prohibitive meaning of a self-governing specialist, these properties might assist us with encouraging specialists helpfully. Table 2 records a few of the properties referenced beforehand. Specialists might be conveniently ordered by the subset of these properties that they appreciate. Each independent specialist, according to us, fulfils the initial four properties (note that this does not suggest that these four, taken together, are comparable to our definition) [7]. Adding different properties delivers possibly valuable classes of specialists, for model, portable, learning specialists. Accordingly, various levelled arrangement dependent on set consideration happens normally. Portable, learning specialists are then a subclass of versatile specialists.

8. Communication Module

With regard to a bioroused plan, we will likely utilize a conventional model to bind together the variety of ideas explicit [8] to the considered biomotivated standards. A recapitulative reflection and examination can be performed on what was introduced in the past segments. In reality, other than the way that MAS, similar to regular frameworks, consider that the frameworks are made out of interfacing elements, there is incredible comparability in the models for portraying biomotivated and MAS approaches. It is feasible to arrange these attributes into two classifications: the intraelement and between substances qualities. At the end of the day, we portray the substances taken separately (atomic; alluding to people) as we describe their connections (made; alluding to a total of people). We notice that a similar truth has been set up for the arrangement of biopropelled standards. We accept that the multispecialist framework approach is normally positioned as a superb contender to go about as a bringing together displaying for biomorphic frameworks.

- (1) The utilization of impact/response standards
 - (i) Able to display simultaneous and joined practices
 - (ii) Abandon the portrayal of the activity as an adjustment of the framework's worldwide state
 - (iii) Improve systems for spreading data to build specialist reactivity
- (2) Disconnecting a communication module (the coupling module). Utilize every one of the impacts delivered at a second to figure out the new condition of the world
- (3) The assurance of the specialist respectability (self-governance) by the differentiation between the decisional framework state factors of a specialist and factors concerning his actual viewpoint
- (4) The unequivocal demonstration of the climate

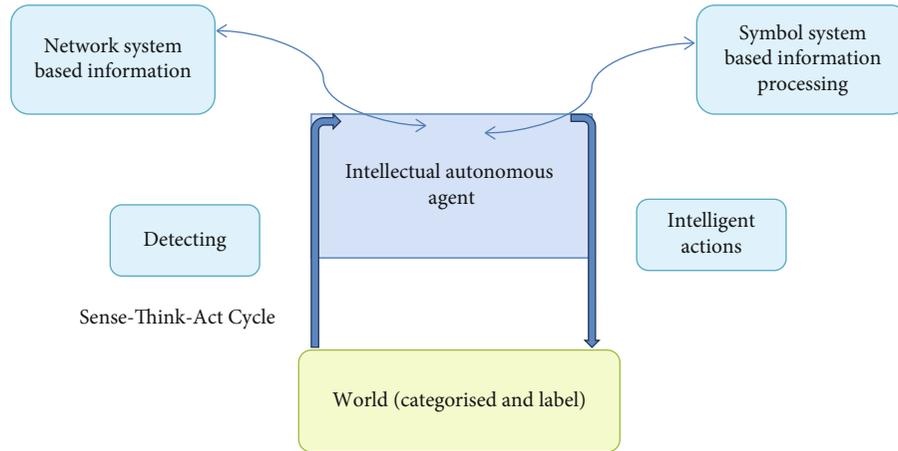


FIGURE 2: Framework based on autonomous system.

TABLE 2: Assets and denotation.

Assets	Other names	Denotation
Responsive	Sensing and acting	Answers in a timely fashion to changes in the environment
Autonomous		Calisthenics control over its own actions
Goal-oriented	Proactive purposeful	Does not simply act in response to the environment
Temporally continuous		Is a continuously running process
Communicative	Socially able	Communicates with other agents, perhaps including people
Learning	Adaptive	Changes its behaviour based on its previous experience
Mobile		Able to transport itself from one machine to another
Flexible		Actions are not scripted
Personality		Believable “personality” and emotional state

9. Simulation and Experiment Design

The rummaging calculation was carried out and tried in robots reenacted in virtual conditions, as a necessity for the advancement with transformative calculations as given in Table 3. Virtual conditions are ideal for a number of reasons, as referenced by [9]; constraint to the actual robots (battery life, sensors, memory, and limitation) and their surroundings (size, and intricacy), moreover, actual tests take any longer to run their course considering a couple of runs for every treatment.

Hence, it was concluded that a virtual recreation would be more suitable. The virtual robots are fit for pushing ahead at variable speed and going to any bearing (0-360°) and are furnished with a solitary light sensor, a battery, and a sun-oriented board. Focusing on the future application on actual stages, every one of the robot’s boundaries is grounded in genuine equipment.

10. Experimental Evaluation of the Computational Model

Importantly, our portrayal expected to be that the data streams adding to static learning, to be specific tangible sources of info and the dead reckoning framework, were

blunder inclined; we created instruments to learn and limit dependably in their essence. Likewise, our model incorporated a system for identifying and overcoming perceptual associating issues. In this part, we depict the aura execution of this computational model and furthermore give consequences of some recreation tests. The outcomes show that our model is equipped for learning places and confining viably. We additionally show that the model scales us with expanding dead-retribution and detecting blunders and creates a compact, multigoal metric portrayal of room.

The reproduction climate for our tests comprised of a generally open room of size 20 × 20 cut-off points, with invulnerable, delimiting dividers. The room likewise contained six indistinguishable landmarks [10]. In our examinations, the robots just addressed milestones in their spatial guides and not the dividers. Predictable with the contributions to the creature hippocampus, we accepted that location and acknowledgment of milestones were performed somewhere else, and just perceived milestone data was given to the spatial learning framework. Further, in many examinations, the sensor ranges were thought to be restricted, which made a portion of the milestones imperceptible from specific situations in the room. For example, with the most extreme detecting range restricted to 10 units, the robot was just fit for identifying milestone 1 or 2 in the concealed areas. Since

TABLE 3: Rundown of robot boundaries, their particular capacities, and standard reenactment esteems.

Robot parameters	Standard value	Application
Vmax	0.5 m/s	Maximum locomotion velocity
In max	1.0A	Optimum solar current
Out max	1.4A	Motor draw at maximum power
BMR	0.2A	Basal metabolic rate: cost of running systems when not moving
Bat max	6 Ah	Battery capacity
Bat charge	20%	Initial battery charge
SensNoise	1%	Sensor noise

every one of the milestones was indistinguishable, these two districts gave one example of perceptual associating in this climate. It ought to be noted, nonetheless, that expanding the most extreme detecting range (e.g., to SO units) is effectively eliminated.

11. Conclusion and Future of Intelligent System Applications

This paper supports contention with instances of issues that emerge from my work on genuine-independent versatile robots. It further contends that the cutting-edge design neglects to resolve the genuine issue of independent specialists and that the purported image establishing issue is an improper reaction to the individuals who have called attention to that the universe of a self-governing specialist does not come prepared sorted furthermore, conveniently marked. An endeavour has been made to catch the quintessence of office in a conventional definition, which permits an unmistakable differentiation between a product specialist and a self-assertive program. The utilization of this definition ought to furnish creators of self-ruling specialists with an agenda of fundamental highlights not to be ignored. What is more, utilizing this definition with additional limitations to helpful subclasses ought to work with interchanges between labourers in the field. We have additionally offered the beginnings of a hypothesis of independent specialists as substances in conditions depicted as dynamical frameworks. This hypothesis, framed as prompting a functional meaning of independent specialist, should assist with explaining the relationship between a specialist being planned and its current circumstance, and in this way work with its plan. The beginnings of a characteristic sort’s scientific classification for self-ruling specialists are proposed, with no guarantees further order through assortments of highlights. The most effective method to proceed or alter this order could well be the subject of a few different papers. There are so numerous conceivable outcomes, each possibly helpful in a specific trend.

Numerous attributes of wise frameworks are promptly pertinent to preparing. Despite the fact that preparation involves a wide range of spaces of aeronautic design, our experience has been with pilot preparation. This framework was executed in a fixed-base reproduction office and was displayed to furnish fundamental drift preparing abilities with no human intercession [11]. The neural organization-based

wise framework adjusts the helicopter elements to the understudy pilot and consequently changes the elements of the helicopter as learning advances. For additional subtleties, it is not too much trouble [12]. Smart frameworks give a method by which complex issues can be tended to and in numerous cases tackled to an acceptable level [13]. The advantages can be ordered as either prompt or later on. The prompt advantages are in the use of smart frameworks to regions where existing philosophies are possibly acceptable and fusing wise frameworks give better efficiencies and arrangements [14–16]. Models include backward plan, versatile control, and ideal look. The future advantages are seriously energizing. Keen frameworks will help plan and take care of issues, for example, cerebrum like control and dynamic, human-machine synergistic work, moment discourse acknowledgment, thought control, human ability improvement, progressed design acknowledgment, ongoing planning, mechanized plan, insightful moving for automated flying vehicles, and self-sufficient security search [17, 18]. On a mindful note, insightful framework analysts ought to look at intently the logical structure of their developments. Insightful structure alongside normalization has been demonstrated to be significant for a definitive pass to genuine executions in airplane applications.

12. Summary and Challenges

Astute specialists have an expansive scope of potential applications and in the interim numerous organizations. Regardless of this, the entrance of specialist innovation in standard programming projects is still rather low. Henceforth, one significant test comprises in making specialist innovation open by giving business off-the-rack arrangements displaying modern strength attributes. The weight to utilize specialist programming additionally exists, since specialist innovation is still an excessive amount of variation from leaving approaches, for example, object-direction or part innovation. A combination with these set up standard methodologies could additionally improve the agreeableness of multigene frameworks and encourage their use. This paper has fundamentally centred on objective coordinated activities—activities that attempt to fulfil a specific inspiration or convey out a goal, by and large towards an item on the planet. In any case, people regularly perform activities that are rather sincerely open—passing on a specific full of feeling state: individual’s grin, shrugs, offer a go-ahead, fold

their arms and scowl, wring their hands, etc. Effectively deciphering such emotional developments is a basic piece of human social communication feeling acknowledgment even viewed as a critical indicator of social capability in youngsters.

Data Availability

Data is available and will be produced when required.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

References

- [1] L. Steels and R. Brooks, Eds., *The Artificial Life Route to 'Artificial Intelligence': Building Situated Embodied Agents*, Lawrence Erlbaum Associates, 1995.
- [2] K. Dautenhahn, *Department of Cybernetics University of Reading*, UK.
- [3] S. H. Rubin, "Intelligent compilation: Bootstrapping case-based learning," *Heuristics: The Journal of Knowledge Engineering*, vol. 5, no. 1, pp. 13–43, 1992.
- [4] K. Akherfi, M. Gerndt, and H. Harroud, "Mobile cloud computing for computation offloading: issues and challenges," *Applied Computing and Informatics*, vol. 14, no. 1, pp. 1–16, 2016.
- [5] G. Lee, H. Park, S. Heo, K.-A. Chang, H. Lee, and H. Kim, "Architecture-aware automatic computation offload for native applications," in *In Proceedings of the 48th International Symposium on Microarchitecture*, pp. 521–532, New York, 2015.
- [6] X. Chen, S. Chen, X. Zeng, X. Zheng, Y. Zhang, and C. Rong, "Framework for context-aware computation offloading in mobile cloud computing," *Journal of Cloud Computing*, vol. 6, no. 1, p. 1, 2017.
- [7] M. Shiraz, A. Gani, A. Shamim, S. Khan, and R. W. Ahmad, "Energy efficient computational offloading framework for mobile cloud computing," *Journal of Grid Computing*, vol. 13, no. 1, pp. 1–18, 2015.
- [8] D. Zeghida, D. Meslati, and N. Bounour, "Bio-IR-M: A Multi-Paradigm Modelling for Bio-Inspired MultiAgent Systems," *Informatica*, vol. 42, pp. 451–466, 2018.
- [9] K. Balakrishnan, "Biologically inspired computational structures and processes for autonomous agents and robots," *Retrospective Theses and Dissertations*, p. 11909, 1998, <https://faculty.ist.psu.edu/vhonavar/Papers/bala-thesis.pdf>.
- [10] T. Wu, C. H. Hu, R. Qin, and Z. Q. Chai, "Design and realization of greenhouse data gathering system based on Freescale MCU," *Advanced Materials Research*, vol. 616, pp. 2083–2086, 2013.
- [11] K. H. Jones, K. N. Lodding, S. Olariu, L. Wilson, and C. Xin, "Sensor networks for situation management: a biomimetic model," in *In MILCOM 2005-2005 IEEE Military Communications Conference*, pp. 1787–1793, Atlantic City, NJ, USA, 2005.
- [12] I. Fister Jr, X. S. Yang, I. Fister, J. Brest, and D. Fister, "A brief review of nature-inspired algorithms for optimization," *Neural and Evolutionary Computing*, vol. 80, no. 3, 2013.
- [13] S. Narasegouda, "Energy aware model for sensor network: a nature inspired algorithm approach," *International Journal of Database Management Systems (IJDMs)*, vol. 6, no. 4, pp. 27–36, 2014.
- [14] B. V. S. Krishna and T. Gnanasekaran, "A systematic study of security issues in Internet-of-Things (IoT)," in *2017 International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC)*, pp. 107–111, Palladam, India, 2017.
- [15] G. T. Reddy, M. P. K. Reddy, K. Lakshmanna et al., "Analysis of dimensionality reduction techniques on big data," *IEEE Access*, vol. 8, pp. 54776–54788, 2020.
- [16] C. Iwendi, P. K. R. Maddikunta, T. R. Gadekallu, K. Lakshmanna, A. K. Bashir, and M. J. Piran, "A metaheuristic optimization approach for energy efficiency in the IoT networks," *Software Practice and Experience*, vol. 51, no. 12, pp. 2558–2571, 2020.
- [17] K. Lakshmanna and N. Khare, "Mining DNA sequence patterns with constraints using hybridization of firefly and group search optimization," *Journal of Intelligent Systems*, vol. 27, no. 3, pp. 349–362, 2018.
- [18] G. T. Reddy, A. Srivatsava, K. Lakshmanna, R. Kaluri, S. Karnam, and G. Nagaraja, "Risk prediction to examine health status with real and synthetic datasets," *Biomedical and Pharmacology Journal*, vol. 10, pp. 1897–1903, 2017.