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# OPTIMIZATION OF MACHINE LEARNING PROCESS VARIABLES IN THE MODELLING OF AUTONOMOUS ROBOTIC MOTIONS

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**Abstract- The growing need for application of four-footed machine-driven intervention in operational environments that are hazardous for humans have informed the need for evaluation of current designs and practices deployed in the design of specialized robots with hopping and height scaling capabilities. The theoretical basis for the hip-hopping condition of this specialized robot types was evaluated in relative analysis and validation of the structural parameters involved in the characteristic hoping nature; which *inter alia*, includes, jumping, height scaling and landing on it fours. The investigation of these capabilities was with the view to optimizing their defining parameters in other to operationalize them in future design of robots with autonomous competences.**

**Consequently, the availability of various advanced application programs and their enabling interface with re-engineered materials results increasing diversification of manufacturing abilities and process conditions; thus, expanding the deployment opportunities for these specialized heuristic machines. The study further narrowed the results of its parameter evaluation to the many possibilities derivable from the integration of AI, augmented analytics, digital twin, virtual realities and other advanced machine and deep learning applications. These digital resources are found to be critical to modern robotic designs as they could be embedded within the central logic controllers designed to receive, interpret and process electro-mechanical signals that are derived from the data acquisition sensors and actuators. It was found that signals and data from these sensors and actuators are further processed for independent decisions and instructions to the robot and this implies a learning process to the robots.**

***Keywords—machine learning, deep learning, hip-hopping, bionic, autonomous robots, artificial intelligence, process variables, structural relativities***

## I INTRODUCTION

Current theories in robotic design and deployment have been premised on two basic types of robotic motions and these are, (i) circumferential motion and (ii) mammalian bionic or walking motion [1]. Unarguably, circumferential robotic motions are applied in environments without elevated contours and geomorphologies, such as surfaced roads or flat pathways like factory floor or hospital walkways.

Consequently, industrial practices have shown that circumferential motion robots have limited applications in environments with undefined cadastral terrain due to their inability to traverse unstructured obstacles or intermittently elevated heights. In furtherance of this investigation, walking or crawling robots are designed to function under reserved but deployable degrees of freedom of motion and multivariable bearing algorithms or code.

This practically imply that upon sensing an obstacle, they can change their defined path but maintain a general sense of their direction. Therefore, based on their multi-variable capabilities and unpredictable hazardous operations and service areas, dynamic motions robots have been designed to function under very harsh and unstructured work environments that ordinarily, human deployment would be too difficult or impossible. Such environment as hazardous gaseous locations, inner surface mining operations, dangerous areas of military and aggression combat zones, outer space applications, etc [2].

In view of the foregoing, since the terrain is unstructured and irregular, it is required that any robot capable of deployment in such terrains must possess the requisite ability, mandatory for navigation in such undefined and complex environment. Further, due to the nature of such terrain, extra-ordinary resilience in terms of efficient movement co-ordination, independent and reliable structural stability and some high level of heuristic proficiency is required to perform task as nearly as possible to human performance. Based on these requirements, it should be noted that the concept of autonomous hip-hopping operationalized robots rely on possibilities of applications under extra-terrestrial and hazardous conditions; thus negating and limiting the application of circumferentially driven robots in such rugged environments.

Accordingly, during concept generation for this specialized robot, structural conditions are also considered as basis for determination of certain design features. For instance, gravitational conditions that are necessary for structural stability of the robots in deployments in unstructured terrains are significantly considered. Thus, this finding has a very crucial design imperative in the sense that an autonomous robot whose design is only premised on earth's gravitational constant would be highly limited in operation when taken to other locations such as, Mars where gravity is 38% reduction of earth's gravitational constant and Moon with 17% reduction of earth's constant. These differences constitute a relative operational problem of structural imbalance. Thus, hip-hopping autonomous robots have capability to maneuver these unstructured obstacles, including structural impediments that are far larger in size as compared to their sizes. Due to heuristic design and programming conditions these type of autonomous device can stretch and scale across sizable canals and dangerous earth's curves in their direction of travel.

This study finds that over the past 20 years, autonomous hip-hopping robots design have undergone various upgrades and parameter re-definitions on account of increasing desire to perform human prone tasks. This benefit has been fueled by innovations in materials technology, such that the discovering of newer materials has enhanced expanding developments in the availability of specialized materials for deployment in various technology driven industries [3]. Accordingly, researches in 2D and 3D motion control sequence has produced single legged hoping capabilities [4, 5].

It should further be noted that more investigations into the possibility of four-footed robots have produced very significant results [6] which partly served as the basis for a 2013 research anticipation that a single-motor-driven and steerable skipping robot could be built and operationalized [7]. These concepts thus produced the Hamed proposed 3-D Bipedal Robots [8] in 2014. In same year, an energy-efficient hip-hopping robot that utilized free vibration energy from a curved beam was invented and tested [9]. Thus, natural movement sequence in different animals have been studied and applied to robotic design in response to varying movement requirements for specialized applications.
In view of the foregoing, this study focuses on optimizing the design predictability factors necessary for the implementation of an autonomous hip-hopping terrestrial robot with multi-variable capability for navigation in difficult or hazardous terrains. Consequently, the manufacturing conditions and template for this proposition utilizes process variables that are incidental to autonomous robotic designs patterned after the transitional movement of certain animals whose general mode of transportation is leaping or hopping [10]. Additionally, an understand-ding of the mechanism of jumping or hopping movement in four-footed animals such as a dog is crucial to the conceptualization of navigation patterns anticipated of the design. Secondly, such designs are pursued in line with the physical outlay of the possible deployment site, in such a way that the bionics or mechanisms of the movement of the animal (dog) is studied with the view to auto-machinate relevant control measures that may make it adaptable to various operational conditions.

Thus, the research emphasizes the analysis of spring like motion conditions of a dog's hip-hopping movement under controlled speed. As shown in Fig. 1 below, the BigDog project applied the elasto-mechanical dynamics of the dog's leg in the modelling of the optimal control measures of the system. Consequently, Holzer and Moses [11] believe that the essence of this model is to probe the applicability of autonomous designs and devices in locations too difficult for human activity.

**Fig: 1** BigDog Project of the Advance Defense Research Projects Agency (Source: Holzer and Moses, 2015)

## MECHANICS OF MODELLING VARIABLES IN THE DESIGN OF AUTONOMOUS HOPPING DOG

The modeling for design of autonomous hip-hopping robots such as the BigDog project (Fig 1) is done by means of observation and imitation of the dog, taking cognizance of its motion dynamics.

It is observed that the dog, like most four footed animals adjusts its posture by moving the forelegs before taking off in a spring like propelled motion. It should be noted that the energy required to spring up, accumulates from the hind legs while the fore legs act as support to create the balance and stability required. In view of the foregoing, this paper observes that the structural relativities required for the spring like motion take-off, of the dog is akin to that of the frog and could be presented in a skeletal front view of the hoping robot as shown in the process schematic diagram of Fig 2 below [12].

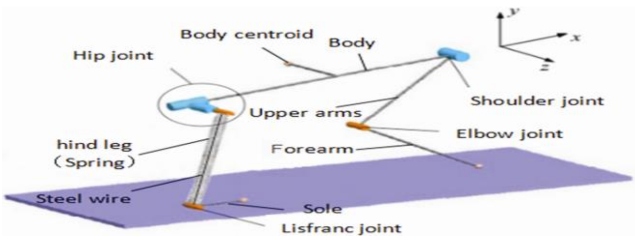


**Fig: 2.** schematic diagram of half side of hopping robot (Source: Zhang et al, 2017)

In Fig. 2 above, the hip-hoping joint, shoulder joint and elbow joint of the frog-inspired hopping robot are theoretically rationalized as a degree of freedom, for which the pre-loaded spring force is selected as the energy storage element that is triggered upon excitation. Further, it should be noted that two degrees of freedom are added to the hip joint, to enable a rotation around the Z and X axis to enhance the structural adjustment of the robot for take-off propulsion force, attitude learning, direction and trajectory.

Consequently, the dynamics of the forelimb function is relatively simple, as the shoulder joint has a degree of freedom (around the Z axis rotation) which is responsible for balance and also enhances the adjustment of the hoping and jumping posture. The elbow joint has a passive degree of freedom to support and shield the robot during the landing phase. This could be further illustrated in Fig 3 below.

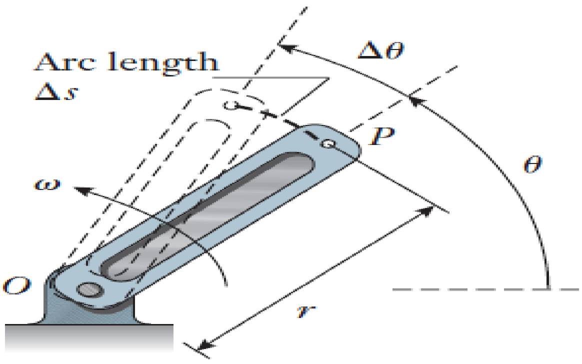


**Fig: 3** rotational motion of a dog-like hind upon take-off represented as a shaft on a joint
(Source: Wickert and Lewis, 2013)

As could be seen in Fig. 3 above, let point *O* represent the hip joint of the modelling dog element and let *P* operate as a motion shaft capable of rotary movement upon the fulcrum at *O*. If the said *P* also represent the body mass of the dog, then the link turns or revolves in a bearing about the center of its shaft and causes a forward spring like thrust movement.

In view of the foregoing, it should be stated that all points on the linking shaft move along concentric energy relative circles. These circles trace their origin to the fulcrum at point *O*, as the operational angle, $\theta$ increases. It should be noted further, that the thrust energy enveloped as $\Delta\theta$ is the positive lower inclination of the dog hind at the point of take-off. This means that, all the energy relative circles collapse into $\theta$, instead of the full rotation angle, $\theta+\Delta\theta$; thus implying that at the point of takeoff, the mass of the dog element is concentrated at the fulcrum under reduced angle of inclination as exemplified in the transition from thrust energy to operational energy, within the limiting value of radius *r*; which is also the length of the shaft and radius of the largest concentric circle in the modeling sequence. This concentration of energy at the operational angle, $\theta$ acts as a spring force to constantly push the shaft upward at an inclined angle = $\theta$, implying that the dog element would only naturally hop at angle $\theta$.

Therefore, the velocity of any point *P* on the shaft is determined by a variable change in position as the rotational angle fluctuate from $\theta$ *to* $\theta+\Delta\theta$ each time *t*, that the dog hops or jumps. In view of this description, as point *P* moves along a circle of radius *r*, the distance that it travels could be measured internally on account of the energy impact per hop. Externally, the distance $\Delta s$, covered could be seen as the geometric arc length determined by equation 1 as:

$$\Delta s = r\Delta\theta \qquad (1)$$

Thus, the dimensionless condition of angle $\theta$ is further observed, when in determination of the value of $\theta$, the ratios of two lengths namely, arc length $\Delta s$ and the radius of the circle *r*, are considered as:

$$\theta = \Delta s/r \qquad (2)$$

Thus, in equation (2) the lengths $\Delta s$ and *r* are expressed in the same units of millimeters, implying that $\theta$ would assume a dimensionless number, determined in radians (rads). Hence dimensional consistency requires that equation (2) is expressed in radians and not in degrees [13].

Further, since velocity of *P* is the distance travelled per unit time, then, with respect to *P*, $v = \Delta s/\Delta t = r(\Delta\theta/\Delta t)$ where $\Delta\theta/\Delta t = \omega$. This analysis thus implies that at the dog's hind limb, the rotational or angular velocity under which movement is possible is given as:

$$v = r\omega \qquad (3)$$

Implying that the angular velocity of travel of the dog element is a function of the mobility of its mass on an inclined plane perpendicular to a ground surface.

## DESIGN OF SPRING ENERGY FOR FORWARD THRUST ROBOTIC DYNAMICS

It should be noted that in consideration for the design of a spring coil as shown in Fig. 4 below, the relevant design parameters as indicated are analyzed, implying that the potential energy capacity for a coil under compression is dependent on the spring rate of the coil expressed as, $K = \frac{Gd^4}{8D^3 N}$, where *d* is the diameter of the spring wire, *D* is the diameter of the spring coil, *G* is the shear modulus of the material and *N* is the number of active coils in the spring. Thus, spring rate is the basis for the encapsulation of the preloaded energy factor referred to as potential energy. The preloaded energy factor in this regard, is the foundation resource pool from where the entire mobility process commences.

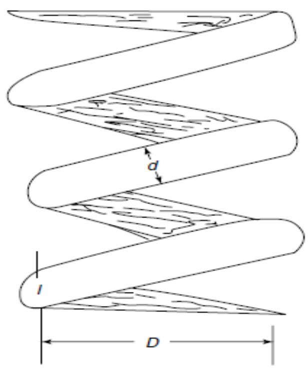


**Fig: 4** spring coil indicating wire and coil diameter. Notice that the compressed and tensioned condition determines the pre-loaded energy

Further, it has been observed that the hind limb of the dog element in the model of this paper rely significantly on the preloaded spring-like force on the biceps of the hind. This natural spring force can be modelled in line with the following parameters under the condition that the parameter satisfy the requirement for equivalent mass and since the spring is a continuum, its stored energy under a preloaded force can be stated in the form of kinetic energy as defined in equation (4) as:

$$\mathrm{KE}_{(\boldsymbol{spring})} = \frac{1}{2}\int v^2(x)dm \qquad (4)$$

Equation (4) further implies that if the mass of the dog element in the model is evenly distributed along the length of the spring, i.e., the hind, then the distributed mass can be analyzed under equation (5) as follows,

$$dm = \frac{m_s}{L}dx \qquad (5)$$

This implies that upon uniform compression, the velocity trajectory profile along the spring can be interpolated between the two extremes of the spring to show that at point $x = 0$, the spring is fixed, while point $x = L$, define a velocity relativity known as $v_L$. In view of this analysis, the spring trajectory velocity for takeoff and sustained momentum can be expressed as:

$$v = \frac{x}{L}v_L \qquad (6)$$

A combination of the process parameters and conditions derived in equations (4) to (6) further yield equation (7) as follows;

$$KE = \frac{1}{2}\int_0^1 \frac{x^2}{L^2}v_L^2\frac{m_s}{L}dx = \frac{1}{2}\frac{m_s v_L^2}{L^3}\int_0^1 x^2 dx = \frac{1}{2}\frac{m_s v_L^2}{L^3}.\frac{L^3}{3} = \frac{1}{2}\frac{m_s}{3}v_L^2 \qquad (7)$$

Evidently, equation (7) is the expression for the complex dynamic energy envelope that propels the dog element. In similarity to the full body mass placed at the vertical end of the compressed spring, $x = L$, i.e.; the mass of the dog element as sustained by its hind under an equivalent mass and can be expressed as:

$$m_{eq} = \frac{m_s}{3} \qquad (8)$$

It should be stated that the imperative of equation (8) to the design and manufacture of this type of autonomous robot is that the modeling sequence can be achieved by representing a combination of an ideal spring with the same spring constant and an equivalent mass of one-third of the spring mass attached to the moving end of the spring. Note that in the instance of this design, the moving end of the spring is the constant impact of the full mass of the dog element on the spring at $x = L$.

## ANALYSIS OF MOTION FORCES AND CONSTRAINTS AS APPLIED TO AUTONOMOUS ROBOTS

In view of the foregoing and in partial agreement with Zhang et al., (2017), this study adopts a modified approach to their four requirements for ideal springing mechanism application in robotic design. This modi- fication is largely due to the application of that idea to autonomous devices with robotic structures. The modified requirements are as follows;

i. process optimization to improve the performance of the autonomous hopping robot as to enable it jump or scale higher and farther;
ii. the hopping direction and angle areadjustable within the range of permissible values;
iii. the attitude of hopping mechanism is controllable in both vertical and horizontal full body trajectories under proper design considerations;
iv. smooth landing is controllable within acceptable design limits.

In order to analyze the characteristics of this bionic mechanism, we can commence with the basic hopping model for the autonomous robot. The vertical and forward thrust motions are conditions that support the hopping motion. Consequently, the views of this study are limited to vertical hopping trajectory since the forward motion is controllable under conditions of modifiable or adaptable attitude which is dependent on the environmental situations the autonomous robot finds itself.

In view of the structural imbalance expected of the robot's hind leg under surface contact conditions, as shown in Fig. 2; certain coordinating parameters of the robot's hind leg in contact phase is hereby defined in satisfaction of the process constraints condition of the center of mass of the robot's hip at point of take-off: thus, the following parameters shall be used for the analysis of the hopping dynamics of the dog element as to model same for the hip-hoping motion capability of the autonomous robot.

a. $h_0$ means initial position, $h_1$ means position at $T_1$;
b. $v_1$ means the velocity at $T_1$.

In view of the foregoing, the hopping motion can be actualized by controlling the attitude and velocity of the robot at the point of take-off. Understandably, the constraint conditions defined above are specific for the vertical upward direction on the basis of the rising center of mass as follows:

$$y(t) = \tau_1 t^3 + \tau_2 t^2 + \tau_3 t + \tau_4 \qquad (9)$$

The constraints expressed above and the state mobility equation (9) operates in the positive y-axis and can be further stated mathematically, as determined in the following constraint equation (10):

$$\begin{cases} y(0) = h_{0,} y`(0) = 0 \\ y(t) = h_{1,} y`(t) = v_1 \end{cases} \qquad (10)$$

Consequent on equation (9) and the boundary limits imposed by equation (10), the state conditions of the hoping trajectory $\tau_i$ (i=1,2,3,3,4) would facilitate the vertical translation of the autonomous robot on the condition that the center of mass of the hip of the dog element at the point of vertical take-off is same defined by the equivalent mass of equation (8) and can further be expressed as a state equation in the upward vertical axis as established by equation (11):

$$y(t) = \left[\frac{2(h_0-h_1)}{T_1^3} + \frac{v_1}{T_1^2}\right] t^3 + \left[\frac{3(h_1-h_0)}{T_1^2} - \frac{v_1}{T_1}\right] t^2 + h_0 \quad (11)$$

## ANALYSIS OF IMPACT FORCES AT POINT OF LANDING

Impact forces associated with the dog element landing in this paper deals the effect of forceful landing on the machine components, elements and sensors connected within the robot structure. In the case of the natural dog element, these forces are absolved by the anatomical coordination of tendons, arteries, and body mass. However, in autonomous robotic designs, these impacts become crucial design criticalities capable of determining the efficiency of design and field performance characterizations. In view of this prevarication of design defect, equation (12) is an imposed constraint with significant limiting functions on possible extreme parameters of the design as detailed below:

$$\begin{cases} y(0) = h_{1,} y`(0) = -v_1 \\ y(T_2) = h_{0,} y`(T_2) = 0 \end{cases} \quad (12)$$

In view of the upward trajectory condition of equation (9) and the boundary limits imposed by equation (12), the mobility state conditions of the hoping trajectory $\tau_i$ (i=1,2,3,3,4) would also facilitate downward gravitat-ional acceleration of the robot on the condition that the center of mass of the hip of the dog element at the point of landing is same defined by the equivalent mass of equation (8) and can further be expressed as a state equation in the downward axis as shown in equation (13) below.

It should be noted that equation (13) did not incorporate the gravitational factor due to the fact that the consideration is for the center of mass of hip of the dog element with respect to height attained, velocity of the landing motion and duration of landing.

Consequently, it is imperative to state that a landing force analysis is necessary for a proper understanding of the vibration signals and nature of impact energy generated during the landing phase of the autonomous robot movement. The study further observed that the generated landing force affects the sensors and structural conditions of the robots. In view of this finding, the application of spring coils with active dampers as have been stated previously in this paper is of crucial design concern. Accordingly, the introduction of spring coils at the hind support is intended to bring about an elastic mobility sequence that is dependent on process control at the point of landing of the autonomous robot.

This controlled elastic measure has the capability of sustainable balancing at landing point over a range of permissible landing surface conditions. Thus, in the analysis that follow, the limiting conditions imposed on the landing point would be considered in order to understand the forces interplay at the center of mass of hip of the dog element. In other to achieve this, the following imposed constraints has the ability to generate equation (13), thus:

a. let $h_1$ of equation (11) become $h_0$ at the landing point;
b. let $-v_1$of the 2nd element of equation (11) become 0 at the landing point;

A structural analysis resulting from the constraint equation of these limiting conditions is further evaluated in equation (13) as follows:

$$y(t) = \left[\frac{2(h_1-h_2)}{T_2^3} - \frac{v_1}{T_2^2}\right] t^3 + \left[\frac{3(h_0-h_1)}{T_2^2} + \frac{2v_1}{T_2}\right] t^2 - v_1 t + h_1$$

*(13)*

where the deferential derivative elements of *y(t)* indicate a reducing equivalent mass balance of the dog element as time,$t \rightarrow 2,1,\ldots.0$ depreciates in the descending order to $t = 0$.

## IMPLEMENTATION OF STRUCTURAL ROBOTIC MOTION ALGORITHMS UNDER MULTI-VARIABLE AI APPLICATIONS

Although, Zhang et al initiated a process order of algorithm design in a flow chart which has an input control from a computer terminal or digital device. The return phase of their control design, is the performance feedback measure, prompting the operator at the control terminal for further action in terms of instructions. However, the views of this paper is significantly different from the proposition of Zhang et al, in this regard, in the sense that in their work, they contemplated robotic designs with a remotely located operator using a computer control terminal.

In this paper we report that the robot for our analysis should be designed to operate as an autonomous machine capable of independent decision making and actions in line with its pre-programed range of behaviors or attitudes in addition to its capacity for futuristic machine learning. This imply that the adjustments expected in the proposed four-footed autonomous robot is on the basis of complex interface of multi-digital sequence programs of different platforms such as AI, IoT, augmented and virtual realities, digital twin derivative applications and other possible machine and deep learning data utilities that are coded into the autonomous robot's implementation memory to enable it perform independent of human or external secondary intervention.

To achieve this level of automation, sensors could be integrated into the robot's infrastructure for higher level self-governance. This imply that our model dog element autonomous robot could be embedded with 3D accelerometers and 3D gyroscopes with inertia sensors linked to the hind spring coils, which upon integration of Robot Haptic Control Interface (RHCI), the sensor component can quickly and at a high sampling rates of information encoding, interpret same and output the processed signals for further instructions generated by the logic controllers of the autonomous robot [14].

Further, the RHCI can also obtain information on the robot's remote location and its structural orientation in such location using the integrated 3D gravitational transducer and magnetic compass [15]; and transmit its data using advanced applications such as edge or cloud computing within the available IoT hub. Other sensors can be embedded at the joints of the robot's fore limb thus creating a coordinating balance between sensors at the rear limb and those at the fore limb. These multi-variable sensors can further be used for measurements of process parameters such as electrical signals, optical, electromagnetic, etc. during vertical take-off or landing operation of the autonomous robot.

Further, in an autonomous system as this, there is also the need for integration of function sensors that are implanted not only to replicate the physical environment of the robot or to convert physical stimuli into machine decipherable gestures, signals or signs but also to increase the precision and reliability of the system by concurrently sensing, distinguishing and measuring the physical effects of the defined parameters on the robots on a real-time basis while the machine is in operation [16].

The study has shown that autonomous mobile devices such as robots and unmanned vehicles have the capability to traverse, navigate and crisscross topologies with structural and environmental uncertainties. This imply that these devices have the potentials for deployment in wide areas of applications and activities, since they are rugged in design and can adapt to changing environments based on their machine learning capabilities. Interestingly, these machines do not get tired due to extreme weather conditions or difficult tasks. Thus, their level of autonomous capability is further enhanced when they are integrated with some level of intelligence as applicable using the AI multi-capacity models or other forms of neural enablement.

In the foregoing regard, a learning based algorithm could be integrated into the robot's memory structure as has been shown that such AI algorithms have been deployed in many fields such as machine performance and health monitoring [17], visual acquisition, learning and understanding [18,19], bio-informatics [20], etc. Interestingly, studies have shown that well designed machines have exhibited better capability to learn even beyond humans in some given tasks [21].

Consequently, all machine learning process is commenced by acquisition of relative data on the condition that the raw data contains the main parameters or key features of the given task. This information must be made in machine readable language for which the machine is enabled to select an appropriate algorithm to generate the corresponding model, which is futuristically adopted as a guideline by the machine in anticipation of possible applications.

Additionally, upon ascertaining and reconstructing of the best model in its memory, the machine will theoretically obey in a consistent manner the embedded instructions of the model; Chen et al, (2019) logically expressed this machine learning process as depicted in Fig 5[22] below:

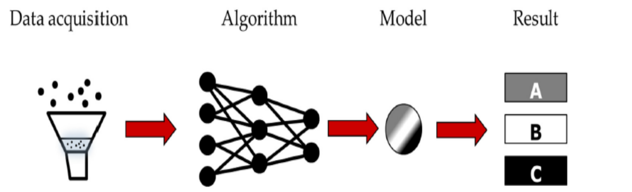


Fig 5: flow chart of machine learning procedure (Source: Chen et. al., 2019)

## INTEGRATED DATA STRUCTURE FOR MOTION CONTROL

In view of the process requirements for an effective motion control system as discussed above, three layers was identified under the relative functional applications. As indicated in Fig 6 below, a process execution level takes care of the activation of the particular software for the assigned task on the basis of the assessment of AI component of the central logic controller.

This initialization process is also a mission planning process that deals with environmental characterization while attitude modulator works with the parameter setting to determine the hopping sequence in accordance with the specific mission instruction. The energy storage actuator is defined for delivery of specific amount of energy sufficient for a given task. For instance, energy requirement at takeoff is different from energy requirement for scaling and landing. This condition is controlled by embedded sensors that measures the amount of energy required and triggers the system for supply of same.

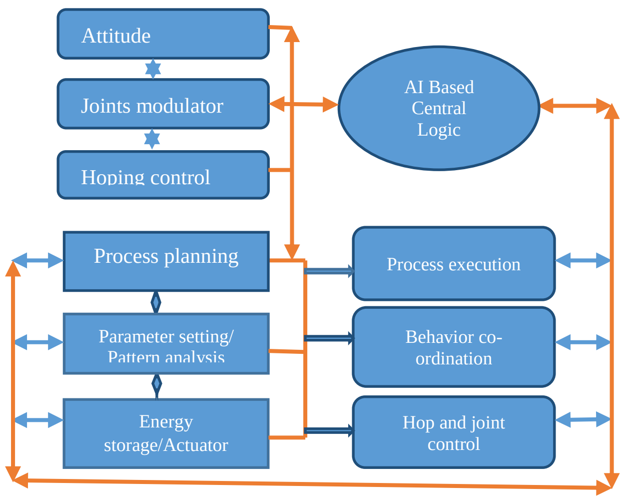


Fig 6: functional areas of AI and integrated programs applications in autonomous robots

It should further be stated that the data signal flow lines in the schematic in Fig 6 above is designed to supply signals using fiber optic or other high speed transmission modes. In this regard, the information transmitted are digitally coded and can only come from or go to the unit intended although all signals use the same fiber optic flow line. Further, the interconnectivity noticed in the design is intended to increase the rate of signal handling and coordination. Thus, the failure of any component or its embedded sensor does not stop the transmission of signal or data from such failed points.

## CONCLUSION

The paper has significantly considered the theoretical dynamics for the operationalization of process variables geared towards the optimization of current technologies in the evaluation natural hopping patterns of four-footed animals with specific reference to dogs. These natural patterns were carefully observed and various structural analysis were performed to define useful parameters that could be exploited and applied to robotic machines with autonomous systems and capabilities. The paper narrowed the mobility analysis and sequence to multi-variable capabilities offered by the AI platform. This platform was analyzed to possess machine learning features for which the robot is taught to self-learn on the basis of programs of instruction embedded into its central logical controllers. A functional diagram as could be seen in Fig 6, was designed to indicate the possible flow of instructional signals and their feedback measures.

Characteristically, the paper posited that the movement of the joints in satisfaction of the target, draws inference from the attitude and hoping control modulators which are programmed and analyzed under appropriate machine languages. The application of Artificial Intelligence as the base program structure upon which all other data programs can interlace makes the venture a complex integration of various software programs that must be designed to be flexible, versatile and capable of upgrade and update in line with changing circumstances.

In view of this need for applicability, the hopping motion of the autonomous robot is achieved by a combination of program sequence modules, which reduce the complexity of the software structure and is amenable to improvements and version upgrades. With current research effort requiring the integration of various programmable platforms and sequence, more advanced control strategy would be implemented in future designs to reduce material requirements and process workloads.

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