Collision-Avoidance System Based on an Insect

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Abstract: Insects' vision system has proven key to the modern day scientific discoveries. Entomological studies have proven that insects have designed a visual system that performs same tasks as those required by RPA's early detection and avoidance of possible predations over a wide field of view otherwise known as collision avoidance. This literature review paper will dissect studies from journals, periodicals, research studies, and graphical impressions on how insects have been key to modeling Collision-Avoidance Systems. It is understandable that all animals and scientific creations are motivated to move without hitting objects within their trajectory

Keywords: algorithm, Collision, Insects, trajectories, translational, Optic, Visual

Introduction

The lifestyle of most advance animals needs significant processing of non-visual sensory data to enable mobility within their immediate environment. For instance, most insects have compound eyes that have additional visual receptors but still rely on non-visual sensory guidance systems. In most studies, Orthopteroid insects have proven to be better models in polysensory controls in that they are nocturnal and often navigate and explore their surroundings with low illuminations hence they are entirely dependent on their antennae for sensory guidance.

Insects possess a variant display of traits that involves attention, simple tools, social learning, emotional state, and metacognition. Most of these traits are largely non-existent in animals higher in the taxonomic level. Insects have their associative learning skills vastly documented with neurogenic and electrophysiological studies indicating such capabilities [1]

Insects have designed a visual system that performs same tasks as those required by RPA's early detection and avoidance of possible predations over a wide field of view otherwise known as collision avoidance. The principle behind designing an insect vision inspired visual system is the realization that insects have eyes are never made to acquire the same level of data that human eye can accommodate.

Under human eye, there is an easy detection of movement in the foveal region signaling the brain to move the eye to view an object in an area of high resolution for a detailed study of the particular object. Rods and cones are particularly key to light absorption and color as visions give a finality of details gathered on the object. As such, a human in the decision-making process then synthesizes the resultant image structures.

Increasing the size of the onboard visual sensors that give pilots a larger instantaneous FOR and deploying numerous sensors that allow for expanded Total Field of View (FOV) are some of the customary approaches used to solve the challenges posed by limited instantaneous field of regard (FOR) [2]. However, the limiting factors are registered in the fact that RPAs are normally small, weight and power usage of onboard sensor systems. An approach based on insect visions gives a reprieve in that it gives a solution that increases general awareness while keeping the size, weight and power consumptions at an all-time low.

Conceptually, movement in a real environment by a victim of visual impairment is based on the ability to detect an object in one's path. Designing an assistive device for people suffering from visual impairment is gravely justifiable by the fact that even though insects may be considered less inferior to humans, they have neural structures and systems that aid their mobility.

Literature Review

There is quite a considerable amount of literature on neurobiology and biomechanics of insect using inherent sensory cells to avoid collision [3]. Reichardt and Hassenstein [4] introduced the concept of estimation of optic flow in correlation-type elementary motion detectors in the 1950s. The trait property of the EMD is that its output is not entirely dependent on the velocity but other factors of the pattern properties such as spatial property and the contrast.

Based on this it is fair to note that nearness obtained from optic flow estimated in insects are closely intertwined with environmental factors. The behavior-based study was proposed on insects to figure out several mechanisms for collision avoidance [6]. This, however, has not borne much since most models have failed to show practical functionality under a berth of condition or they do not consider the use of optic flow measured by correlation-type elementary motion detectors.

Some studies have been based on insect-related visual systems. The studies have shown that mobility insects are based on an Elementary Motion Detector (EMD). EMD otherwise known as Hassenstein-Reichardt detector gained credence by physiological and behavioral models that showed that from the studies done on cells within the optic lobes of the insect, there are some considerable correlations with information from the retina based photoreceptors that are key to encoding motion information “[6]”, “[7]”

Analog to rods and cones are some of the insect receptors just outside the eye that aid them to sample a wide visual field concurrently. Data gathered by the receptors, ommatidia, an integrated with their brains have specific functionality, but all connected to survivability. The determination of suitability of ommatidia is subject to Ability to detect movement over a wide area, FOV; calculations of speed and direction of movements of the objects in the FOV; Determination whether the object in view is either a threat or food and detection ability to find their way back to their nests [8].

It is plain that traits like high resolution and color vision are not key to the performance of basic functionalities. Many studies on insect vision have employed simplicity of the design of the insect eye as a foundation to make a lightweight wide field sensory system. Information obtained by the designed systems are then analyzed by the aid of innovative parallel identification processing systems which enable data procession in near-real time. In the paper on the information processing in mind and machine, the result of the studies carried out is that lightweight and intelligent sensing systems easily performs the sense and avoids any other functions for remotely piloted aircrafts [9].

A bio-inspired obstacle avoidance system concept research paper for visually is impaired people realized that a bio-inspired obstacle avoidance system in the concept of making a device that can be used to aid visually impaired person [10]. Reichard correlator came out as the idea that was inspired by the insect visual systems based on the previous studies and existing applications that designed and replicated a system that was suited to the purpose [10]. The said modifications were an act of a pre-processing part of extraction in the field of interest from the entire visual arena that guaranteed the better functionality of the system as well as improved data processing. Other significant improvements were on the decision-making part of the creation of a dependency for threshold with engrained signals that resulted in accuracy in obstacle detection.

For any mobile agent whether biological or technical, collision avoidance bases as one of the fundamental need hence the spirited search to have collision free discoveries in the techno world. Appreciation comes from the fact that several studies have been conducted and are still being carried out in a bid to achieve precise solutions to the challenges that man face today. Modeled study on collision avoidance technology is greatly inspired by insect behavioral studies and by looking into the traits of the optic flow in a spherically experienced eye [11].

Computerized systems have the capacity to allow independent navigation of mobile robots that hugely based on the insects' visual systems. The works give a framework for the development of highly precise collision sensors, surveillance, and video programming games. Insects have a specialized way of processing data through electrical and chemical signals that equip them with quick, fast and correct warning systems for the avoidance of collisions [12].

Study journals affirm that insects are smartly suited for the unpredictability of their environments [13]. They have optic flow neurons that are visually sensitive to motion. Moreover, flying insects depend on visual motion during their movements such as during takeoff, landing, tunnel cross and both frontal and lateral obstacle avoidance as well as adjustment of speed in a cluttered surrounding

Optic flow is a vector field of an impending motion of surfaces, objects and edges in a visual scene as generated by relative motion between the scene and the observer [13]. Of , translational optic flow is centered on short-range navigation because it is reliant on the ration between the relative linear speed of visual scene to the observer and the relative distance of the observer from barriers in the immediate environment minus any form of direct measurement of the either speed.

Vision is key to the survival and interaction of all species, and all perceived low order animals have remarkable visual processing capacity. It is worth noting that insects are capable of active separation of translational optic flows by the behavior of using the saccadic strategy of flight and controlled glazed. Optic flow felt during translations have data on the structural depth of the environment even though the information is entangled with the ones on self-motion [11].

The bio model acquires the structural broadness from translational optic flows eased by local properties of the spherical eyes. As a result, the course of agent locomotion is computed in a systematic way to prevent occurrence of any collision. One of the prevalent and observable response is the stop of motion just before the obstacle this is however varied in the sense that some insects move vertically to climb over the barriers, circumvention of the barrier as well as movement in a reverse direction. From the study, collision avoidance strategy chosen is dependent on the configuration of the obstacle its sheer size.

A study on collision avoidance by running insect seen cockroaches' pattern of running with an obstacle path in a video graphics method [14]. The aim of the study was the determination of the range of possible reactions to obstacles and the sensory mechanisms used to trigger their reactions.

Broadly, insects apply the correlation-type elementary motion detection to measure and examine optic flows. As such, their responses are hugely dependent texture and contrast of the objects as well as its velocity. The use of geometrically figured out optic flow as significant to factor collision avoidance as viewed under closed-loop conditions. Additionally, an algorithm to figure out the correlation-type elementary movement was conducted with results showing success in the collision avoidance [11]. The correlation type elementary motion sensors that are an essential capability of insects in circumnavigating collision has been utilized to advance collision evasion in simple and multifaceted surroundings. As a result, geometric optic flows characterize the established models. These models take into consideration that motion is the principal source of information on the structural depth of a surrounding. Therefore, it causes collision prevention functions.

The range of environments has proven successful in the transfer from geometrical optic flow to bio-based correlation type. Additionally, if collision avoidance algorithm is fused with a goal direction, the coupling between collision avoidance and goal direction enable agents to move through cluttered environments even when such objects, floors, and their backgrounds are covered with a similar texture. Moreover, trajectories have shown to travel in cluttered environments exhibit similarities regardless of the state of starting conditions.

There are further underlying assumptions that algorithm has some similarity from the optic flow [15]. Some of these are: a translation phase that incorporates several directions of motion; a spherical eye; movements agents can only occur in a null elevation plane. The second assumption is the required order that average out characteristic singularities in the translational optic flow field by integration of optic-flow amplitudes acquired when movements are in different directions.

Contrary to algorithm nearness calculation, the assumption is that agents fundamentally move in a null elevation plane and not in any way satisfied in a free-flying insect is that when circumventing flights, height changes occur to a much smaller margin compared to the horizontal plane. However, an error proportionate to upward movement is noted when an agent move in another direction than in the null elevation is estimated to be near the algorithm [16].

There is a distinction along the body of the long axis between in the direction of translation orientations and the saccades of flying insects. Based on this, the relationship between sideways and forward movement part has a systemic change between two consecutive saccades [15]. However, considerable, and progressive changes in the ration of sideways to forward translational components at times occur as a result of inertia when and if almost all saccades with the strength to propel the changes rely on saccade amplitude [5].

Based on findings, it is worth noting that flying insect may average the optic flows that are generated on the eyes during the progressive intersaccadic transformations along the flight paths and obtain relative proximity to figure out the amplitude and the path of the next saccade [15]. A resultant effect of the unavoidable time constant of the movements of the detection system has an Elementary Motion Detector that responds while following a saccade that may equally be affected by the rotational optic flow of the earlier saccade. A study strongly opines that rotational part of the optic flow may in principle be removed if there are known agents of angular velocity [16]. As such, this transformation will not be straightforward on concerning EMD motion measurement since they are entirely dependent on environmental texture.

It is the goal of the object, biological or technical to reach their desired destinations along their trajectories without hitting an object along the way. Thus, in the contemporary world, path integration and visual navigation is the goal direction [17]. As a matter of principle, when in a cluttered environment, an agent needs a combination of goal direction and collision avoidance.

In some cases, Collision Avoidance Algorithm acts symbiotically with goal direction by use of CAN that leads to traits that may show some sort of a compromised between reaching the goal or avoiding a collision. Moreover, there is the tendency of convergence on a limited number of specific routes that are mostly independent of the starting position for agents in complex, cluttered environments [18].

In a review explores that explores the overview of optic base collision free means from a biorobot perspective, it infers that flying insects are hugely reliant on the optic place as a way of circumvention of obstacles in their unfamiliar setting hence drawing an enormous focus on optic flow based strategy [19]. The review is further conversant with the fact that loads of time and resources have been spent on studies about optic flow based robotic over the last two decades to gain an understanding as to how robots can use insect-based optic flow during their movements.

In the field of robotics, Coombs and Roberts developed the concept of speed control system based on optic flow. As such, mobile robots had its forward speed adjusted by keeping optical flow within attainable range by the aid of bilateral optic flow to control its mobility [20]. Inspired by Robee, Santos-Victor developed bilateral optic flow criterion as a feedback meant to control the robots speed that was tuned in by optic flow based algorithm. Understandably, the surrounding visual clutter mostly controlled the speed of the robot.

Robotic studies and Bees showed similar biological traits [21]. This was notable in that bees appeared to employ the use of identical optic flow-based strategy to control their flight in narrowed corridors or in straight passages that have manipulated textures. This is so because when bees move through narrowed corridors, there is a reduction in the speed of the flight and it increases when broadened. This observation suggests that equipping bees with an optic regulator may lead to adjustment of the flight through regulation and monitoring of the optic flows as perceived by their motion sensitive system [22].

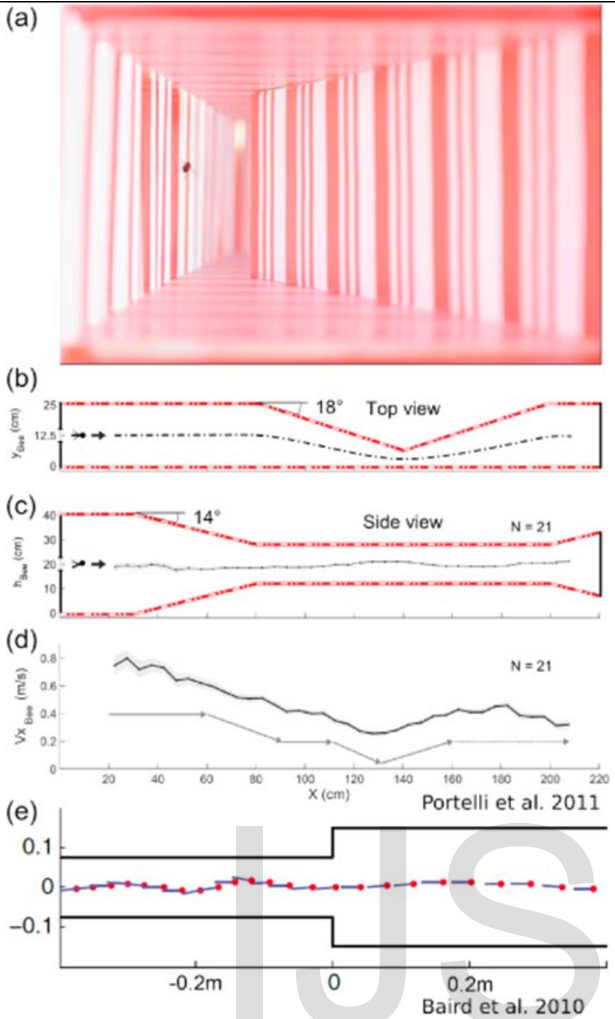

Fig. 1. (a) A honeybee flying along the doubly tapered tunnel

(b) Top view of the tunnel shows bee's entrance, the part narrowing in the horizontal plane and the approximated flight path of the bee in the horizontal plane with reference to the "adjusting response".

(c) Side view of the narrowed tunnel, exhibiting the vertical tightening. The mean flight path of the honeybees is determined as a function of the distance along the abscissa. The bees' mean flight can be viewed to be practically vertically placed in the entire tunnel (height h = 19 ± 0.16 cm).

(d) Ground speed profile along the tunnel. The honeybees reduced their speed as the tunnel tapered and increased their speed as it broadened. The faded trace around the curves provides ± the standard error of the mean. The gray profile below the main curve exhibits the overall flight speed pattern as examined [23].

(e) The honeybees flew at low speed as the tunnel was tapered and amplified their speed when widened abruptly [24].

Conclusion

As proven in the expansive and extensive desktop analysis, several results show that insects have a huge endowment with vision more so those that use optic flow based strategy. Some of the variant traits that make up simple tool, sensory attributes, social learning, and metacognition are non-existent in higher taxonomic animals. Additionally, not all common visual strategies of insects and other lower animals have exhaustively been examined giving room for more bio-based and interdisciplinary approaches to the studies.

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