

Immersive Visual Analysis of Insect Flight Behaviour

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Figure 1: Immersive visualization of bee flight behaviour. The bird's-eye view provides a global view of the virtual environment with flight paths in a 3D geo-spatial context. The tracking viewpoint (bottom left) provides a close-up perspective on bee flight movements. A drop down menu allows to change different attributes of the tracking data and related visualisation of the paths.

ABSTRACT

We present *I-Flight*, a virtual reality based visual analysis system for insect movement data. *I-Flight* aids in understanding insect movements and collective flight behaviour in a simulated environment. Towards this end, *I-Flight* visualises insect flight paths in their natural, 3D geo-spatial context. In this paper, we demonstrate the use of *I-Flight* for honey bee flight data and related environmental variables. The system is designed to be extendible to other insect flight data by adopting the data attribute space and the respective mapping onto visual variables, such as colours. The value of the presented *I-Flight* system is not only in complementing existing scientific methods and tools for understanding honey bee behaviour, but also in raising broader awareness for honey bee preservation through an engaging, immersive environment.

Index Terms: H.5.1 [Information Interfaces and Presentation (e.g., HCI)]: Multimedia, Information Systems; H.5.2 [Information Interfaces and Presentation (e.g., HCI)]: User Interfaces (D.2.2, H.1.2, I.5.6)

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1 INTRODUCTION

Foraging and collecting food are essential behaviours of insects to secure their own survival and that of the colony. Understanding foraging behaviour is of great interest to the scientific community and to ecologists in particular. For insect species that feed on plants, for instance honey bees, these activities involve a large range of collective behaviours as a swarm, from forming foraging strategies (increased activity that maximises their chances of encountering a plant, completely random activity, or sensory attraction to a plant from a distance) to executing the exploration phase and periodically monitoring food availability [11]. These activities are repeated in flight cycles that are established and partially decided by environmental factors, including air temperature, humidity, precipitation, and time of day. Ecologists have uncovered many peculiar flight movements of insects, such as rapid changes in flight direction, vertical take-off and landing, upside-down flying, and lateral and backward movement [5, 14].

The study of insect flight has been advanced in recent years but most of the visualisation work focused on flow features and wing aerodynamics during flight via conventional desktop displays [4, 10]. With the rise of commercial head mounted displays, such as Oculus Rift¹ and HTC Vive², immersive technology has become more accessible. Previous studies comparing immersive technology with desktop displays demonstrated the benefits of immersion in acquisition of spatial knowledge [1, 9]. In this paper we therefore explore virtual reality for immersive visual analysis of insect flight

¹<https://www.oculus.com/>

²<https://www.vrset.com/>

Flight Behaviour Migrat Insect

Hussin A.Rothana



Flight Behaviour Migrant Insect:

Flight Behaviour and Migration of Insect Pests D. R. Reynolds, J. R. Riley, 1997 Knowledge of the flight behaviour of migrant insect pests is essential for an understanding of their population dynamics which in turn determine the design of efficient management strategies This bulletin provides a detailed review of the development of radar entomology spanning the last 30 years and its contribution to the study of major insect pests of agriculture and human health in the developing world Pests include grasshoppers and locusts the African armyworm rice brown planthopper and other rice pests the old world bollworm and some mosquito vectors of human diseases

Insect Migration V. Alistair Drake, A. Gavin Gatehouse, 1995-09-14 A comprehensive account of insect migration in its ecological and evolutionary context Evolution of Insect Migration and Diapause H. Dingle, 2012-12-06 This volume is an outgrowth of a Symposium entitled Evolution of Escape in Space and Time held at the XV International Congress of Entomology in Washington D C USA in August 1976 The choice of topic was prompted by recent advances in evolutionary ecology and the apparent suitability of insect migration and diapause as appropriate material for evolutionary studies In the event that choice seems amply justified as I hope a perusal of these papers will show These Symposium papers hardly cover the topic of the evolution of escape mechanisms exhaustively and I am sure everyone will have his favorite lacuna Some of the more obvious ones are indicated by Professor Southwood in his Concluding Remarks at the end of the book The purpose of the Symposium however was not complete coverage but rather to indicate the potential inherent in insect migration and diapause for the study of evolutionary problems In that I think we have succeeded reasonably well These papers are expanded and in some cases somewhat altered versions of the papers delivered in Washington This has allowed greater coverage of the topics in question I suggested a format of a general overview of a topic emphasizing the author's own research contributions In general the papers follow this outline although emphases vary Two of the authors Dr Rainey and Dr Lumme were unable to attend the Symposium Dr Rainey's paper was read by Mr Frank Walsh but Dr Migration : The Biology of Life on the Move Davis Hugh Dingle Professor in the Department of Entomology and Center for Population Biology University of California, 1996-01-18 Migration is one of the most fascinating and dramatic of all animal behaviors Historically however the study of migration has been fragmented with ornithologists entomologists and marine biologists paying little attention to work outside their own fields This treatment of the subject shows how comparisons across taxa can in fact illuminate migratory life cycles and the relation of migration to other movements The book thus takes an integrated ecological perspective focusing on migration as a biological phenomenon The work is divided into four parts each with a brief introductory section Part I defines migration gives examples and places migration in the spectrum of movement behaviors concluding with a chapter on methods for its study Part II focuses on proximate mechanisms including physiology and morphology and the constraints associated with them the interactions between migration and wind and current patterns and the various orientation and navigation mechanisms by which migrants

find their way about Part III on the evolution of migratory life histories addresses the evolutionary and ecological basis for migration and the roles of migration not only in the lives of organisms but also in the ecological communities in which they live Part IV is devoted to a brief consideration of migration and its relation to pest management and conservation As a major contribution to a vital subject this work will be valued by all researchers and students in the field of animal behavior ecology and zoology

Pesticides Documentation Bulletin, 1968

Insect Flight Graham J. Goldsworthy, 2018-02-01 Insects are the most numerous class of animals on earth both in terms of their number and their variety There are 800 000 recognized species with between 1 and 10 million estimated species yet to be classified This book will discuss mechanics of flight Wing structure Hovering flight flight in smaller and larger insects and wing polars

Insect Ecomorphology Oliver Betz, 2025-02-25 **Insect Ecomorphology Linking Functional Insect Morphology to Ecology and Evolution** offers the most up to date knowledge and understanding of the morphology of insects and the functional basis of their diversity This book covers the form and function of insect body structures synthesized with their physiological performance capabilities biological roles and evolutionary histories Written by international experts this book provides a modern outline of the topic exploring the ecomorphology of functional systems such as insect feeding locomotion sensing and reproduction The combination of conceptual and review chapters methodological approaches and case studies enables readers to delve into active research fields and attain a general idea of the explanatory power of the form function performance paradigm The book uncovers key structures of the different regions of the insect body elucidates how they function and investigates their ecological and evolutionary implications **Insect Ecomorphology Linking Functional Insect Morphology to Ecology and Evolution** is a vital resource for entomologists biologists and zoologists especially those seeking to better understand the morphology and physiological impacts tying insects to environments and evolution Integrates traditionally separate fields of research with the aim of understanding insect morphology ecology and evolution Considers the impacts of insect ecomorphology on biomimetic applications Includes conceptual and methodological chapters to help readers appreciate the ways in which ecomorphological studies are performed

Radar Entomology V. Alistair Drake, 2012 Many of the world's most serious agricultural pests are highly migratory Through the use of special purpose radars we are provided with insights into their movement and how they learn about and navigate through their environment This text examines the behaviour and regional variations of these species as well as the altitude of migration concentration of insects in layers and how they respond to large and small scale wind systems The book relates radar observation of insect movement to complementary and competing methodologies and surveys its capabilities and limitations It also deals with

Energy Metabolism in Insects Roger G. H. Downer, 2012-12-06 The scientific program for the XVI International Congress of Entomology held in Kyoto Japan August 3-9 1980 included a symposium on the subject of Energy Metabolism and Its Regulation in Insects The symposium provided an opportunity to integrate knowledge and focus attention on an important and fundamental aspect of insect biochemistry

physiology The energy metabolism of insects differs from that of other animals in a variety of ways including the prodigious amounts of energy expended by flying insects the presence in hemolymph of large concentrations of sugar in the form of the nonreducing disaccharide trehalose the transport of fat in the form of diacylglycerol and the periodic mobilization and deposition of cuticular components during development These differences together with hormones neurohormones and neurotransmitters that are specific to or functionally different in insects serve to demonstrate the unique nature of energy metabolism in insects An obvious corollary from the demonstrated uniqueness of insect energy metabolism is that an understanding of the process may lead to the development of new specific agents or strategies for the suppression of insect pests The present volume is an expanded version of the Kyoto symposium Seasonal Adaptations of Insects Maurice J. Tauber, Catherine A. Tauber, Shinzō Masaki, 1986 A comprehensive discussion of the broad range of insect responses to seasonality and a critical interpretation of the scientific literature **Encyclopedia of Animal Behavior**, 2019-01-21

Encyclopedia of Animal Behavior Second Edition Four Volume Set the latest update since the 2010 release builds upon the solid foundation established in the first edition Updated sections include Host parasite interactions Vertebrate social behavior and the introduction of overview essays that boost the book's comprehensive detail The structure for the work is modified to accommodate a better grouping of subjects Some chapters have been reshuffled with section headings combined or modified Represents a one stop resource for scientifically reliable information on animal behavior Provides comparative approaches including the perspective of evolutionary biologists physiologists endocrinologists neuroscientists and psychologists Includes multimedia features in the online version that offer accessible tools to readers looking to deepen their understanding Innovative Pest Management Approaches for the 21st Century Akshay Kumar Chakravarthy, 2020-03-20

Several Integrated Pest Management IPM approaches are available for managing pests of varied kinds including individual and integrated methods for pest suppression Recently the focus has shifted to pest management tools that act on insect systems selectively are compatible with the environment and are not harmful for ecosystems Other approaches target specific biochemical and physiological aspects of insect metabolism and involve biotechnological and genetic manipulation Still other approaches include the use of nanotechnology endophytes optical and sonic manipulation to detect and control pest insects Unfortunately conventional forms of pest management do not focus on technology transfer to the ground level workers and farmers As a result farmers are incurring huge losses of crops and revenues This book highlights the importance of using communication tools in pest management and demonstrates some success stories of utilizing automated unmanned technologies in this context The content is divided into three sections the first of which Pest Population Monitoring Modern Tools covers long and short range pest population monitoring techniques and tools such as satellites unmanned aerial vehicles drones remote sensing digital tools like GIS GPS for mapping lidar mobile apps software systems artificial diet designs and functional diversity of info chemicals The second section of the book is devoted to Emerging Areas in Pest

Management and offers a glimpse of diversified tactics that have been developed to contain and suppress pest populations such as endophytes insect vectors of phytoplasma Hymenopterans parasitoids mass production and utilization of NPV etc In turn the third section focuses on Integrated Pest Management and presents farming situations that illustrate how research in diversified aspects has helped to find solutions to specific pest problems and how some new and evolving tactics can be practically implemented Given its scope the book offers a valuable asset for entomology and plant pathology researchers students of zoology and plant protection and readers whose work involves agriculture horticulture forestry and other ecosystems

Aquatic Insects Kleber Del-Claro, Rhainer Guillermo, 2019-06-10 This book presents a broad view of the ecology and behavior of aquatic insects raising awareness of this conspicuous and yet little known fauna that inhabits inland waterbodies such as rivers lakes and streams and is particularly abundant and diverse in tropical ecosystems The chapters address topics such as distribution dispersal territoriality mating behavior parental care and the role of sensory systems in the response to external and internal cues In the context of ecology it discusses aquatic insects as bio indicators that may be used to assess environmental disturbances either in protected or urban areas and provides insights into how genetic connectivity can support the development of novel conservation strategies It also explores how aquatic insects can inspire solutions for various problems faced by modern society presenting examples in the fields of material science optics sensorics and robotics

Migration Hugh Dingle, 2014 A broad multi specific overview of the physiology ecology and evolution of migration discussing and analysing migration across a full taxonomic range of organisms from primitive plants to classic migrants such as butterflies whales and birds

Endocrinology II G. A. Kerkut, 2013-10-22 Endocrinology II concerns the actions of hormones in insects complementing Volume 7 which is concerned with the production and chemistry of insect hormones While the preceding volume is directed mainly towards the insect endocrinologist this volume has much of intrinsic interest to the general physiologist It deals with the regulation of metabolism reproduction cuticle properties and certain aspects of behaviour from a systems point of view and amply documents how hormones have provided basic insights into the functioning of such systems Interference in endocrine regulation could provide future systems for insect control and this volume will provide the foundation on which the future formulation of these strategies is based More information on diverse aspects of insect hormone action is brought together here than in any previous single work and this volume will therefore be a valuable reference source for many years to come

Video Techniques in Animal Ecology and Behaviour S.D. Wratten, 2012-12-06 This book is about video techniques not video technology To deal with the latter would be a thankless task as by the time the book was published it would be out of date given the rapid rate of development of video hardware However these technological advances do help to make it an exciting field As Joe Riley says in Chapter 1 Advances in video technology continually produce improvements in performance and reductions in both the cost and size of equipment so it seems certain that the technique will prove to be an even more useful resource in the future In selecting the topics and

authors represented in this book I have tried to encompass most of the behavioural and ecological uses to which video is likely to be put over the next decade or so I believe the book has captured the invaluable accumulated experience of the most active practitioners of the medium in this research area The idea for the book arose from two workshops on the use of video in ecology and behaviour held at Southampton University UK during the 1980s Three learned societies were involved in these meetings the Association of Applied Biologists the British Ecological Society and the Society for Experimental Biology

Advances in Insect Physiology ,2019-05-21 Advances in Insect Physiology Volume 56 provides readers with the latest interdisciplinary reviews on the topic It is an essential reference source for invertebrate physiologists neurobiologists entomologists zoologists and insect chemists with this new release focusing on the Effects of resource limitation on the strengths of tradeoffs in insect lifecycles The circadian system in insects cellular molecular and functional organization Molecular Physiology of the Insect Midgut The Cryptonephridic system in Lepidoptera Subsocial insects and the physiology of parental care Mechanisms regulating phenotypically plastic traits in wing polymorphic insects and more **Proceedings of the 9th International Symposium on Insect-Plant Relationships** Erich Städler,Martine Rowell-Rahier,Robert Baur,2012-12-06 The 9th International Symposium on Insect Plant Relationships SIP 9 was once more following the tradition established in 1958 a forum for investigators in both basic and applied entomology interested in the important and fascinating field of interactions between plants and insects We were pleased and honoured to organise this symposium which took place June 24 30 1995 in Gwatt on the shores of the Lake of Thun in Switzerland 168 participants from 26 countries from all over the world actively took part in the symposium by contributing 12 key note lectures and a total of 141 oral presentations and posters The favourable response and the lively interaction of the participants in all symposium activities is the clearest indication of the success of SIP 9 The organisers appreciated the enthusiasm and the willingness to collaborate shown by all participants The following volume contains written contributions 72 of only half of all presentations This is due to the fact that we decided to produce not only an account of the proceedings but also to publish all contributions as a special volume of the journal Entomologia Experimentalis et Applicata This procedure was last adopted in 1978 for SIP 4 organised by Reginald F Chapman and Elizabeth A Bernays and ensures a wide distribution of the papers within the scientific community and easy access through libraries Inevitably we had to employ the same review procedure as applicable for the manuscripts regularly submitted to Entomologia Insect Flight Wijesiri Danthanarayana,2012-12-06 **Perspectives in Insect Behaviour** M. L. Agarwal,2009

The Enigmatic Realm of **Flight Behaviour Migrat Insect**: Unleashing the Language is Inner Magic

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