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Mini-Symposia Title: The New Domain of Internet of Things and Big Data: Wildlife Conservation

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Theme:

- 09. Therapeutic &Diagnostic Systems and Technologies
- 12. Translational Engineering for Healthcare Innovation and Commercialization

Mini-Symposia Synopsis

Mini-Symposia Synopsis— Max 2000 Characters

Veracity, value, viscosity, validity, volatility, variability, and viability have characterized data during the last decade with the extensive use of artificial intelligence and machine learning to research, discover and interpret knowledge within data, transforming mining into analytics. The revolution of data and connectivity of the 21st century left behind one of the most fragile parts of our planet and yet to be connected. According to the International Union for the Conservation of Nature (IUCN) 120,372 species were assessed in 2020, with 20% categorized as “data deficient”.1,2 When a species is categorized as data deficient that prevents the species from appearing in the Red List of endangered animals and therefore that species does not receive the attention needed for preservation and conservation. It is not only wild exotic animals that lack data for a better understanding of their habit, anatomy, physiology and health; Some species already extinct in the wild have been preserved in zoos. Recently, zoos have become a great researchable source of collections of captive unique and irreplaceable species and represent a fundamental key in the progress of conservation. The development of novel technologies though data and information may enable professionals such as veterinarians and zoologists to understand animal behavioral and physiological responses with a depth never before studied, thus playing an important role in species conservation.

This Symposia aims to present the technological challenges veterinarians, biologists and zoologists face when caring for exotic animals in the wild or in captivity and how technology is enabling the improvement of animal welfare by promoting preservation and protection of endangered species. Monitoring exotic animal patients can be a very challenging task due to their unique anatomy, physiology and habitat. Dr. Lomas will share her experience and technological challenges when caring for marine turtles in the wild of the Maldives. Dr. Cusack will speak to the challenges facing wildlife and exotic veterinarians. Mr. Cibis will present the engineering challenges of developing underwater technologies and the potential benefits of this technology for animals in the wild or captivity. Mr. DeJong will present the technological challenges of caring for the largest collection of animal species in Canada when sharing his experience at the Toronto Zoo. Dr. Bressan will present the opportunities for engineering solutions when addressing the monitoring of exotic animals in the wild or in captivity.

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Underwater Technology for Marine Animal Monitoring and Diagnostics

T. Cibis, Joint Research Centre in AI for Health and Wellness, University of Technology Sydney, Australia; N. Bressan, Faculty, University of Prince Edward Island, PE, Canada,

Abstract— **Marine animals show a unique physiological functionality when compared to humans. The functionality is thereby directed towards an optimal adaptation to the underwater environment. Studying the animal's physiology during underwater exposure could provide data for veterinarians to monitor and diagnose marine animals. However, monitoring technologies for underwater application require a specialized design and operability to enable ensure data acquisition.**

I. INTRODUCTION

There are at least 226,408 marine species with some of the oldest species like the frilled shark being 150 million years old. Marine life adapted through the centuries to the greatest diverse environment the oceans. The marine species adapted morphologically, physiologically and behaviorally, such as the crab larvae's use sound to find habitats where they metamorphose; sea stars use chemicals to fight predators due to their slow movement, and dolphins developed a nostril on the top of their heads, the blowholes, to breath and communicate. Studying such diverse collection of animals it is fascinating and represents new challenges for monitoring and diagnosis.

Water, compared to atmospheric conditions, has the property of high electrical conductivity. This conductivity causes any device which operates on electro-potential measurements to fail in underwater conditions [4]. These devices, such as an ECG or EMG measure electro-potentials on the body's surface. In underwater conditions these electro-potentials are significantly reduced due to the good electrical conductivity of water [4].

Furthermore, any device settings, and implemented filters are optimized to monitor biomedical signals in the human's physiology range and skin. However, the physiology range of marine animals can vary significantly compared to humans and the electrode-skin interface as present in humans may vary to the skin anatomy of marine animals. For ideal monitoring and data acquisition of marine animals these challenges need to be addressed.

II. METHODS

One method of underwater biomedical signal monitoring was introduced by von Tscharner et al. [1, 2, 3] And later modified by Gradl et al. [4] Rather than measuring electro-potentials, the new approach focused on the measurement of subcutaneous current flows. These current flows were assumed to correlate with the surface electro-potentials and would provide identical physiological information [2,3]. This current measurement technique was demonstrated to be applicable underwater [3,4].

III. DISCUSSION & CONCLUSION

Considering the current measurement technique, the monitoring of marine animal's physiology in underwater setting can be realized. A prior knowledge about the specific physiology ranges of marine animals would allow to optimize the device for the animal of interest to be monitored.

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The New Domain of Internet of Things and Big Data: Wildlife Conservation

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Abstract— **IoT systems are defined by the interaction between the physical and the digital environment with the ability to communicate efficiently translating data into information [1]. The lack of technology to monitor and understand animals under the care of humans represents one of the great challenges for preservation and conservation.**

IV. Introduction

Clinical Decision Supports Systems have been developed since the 60's with Gorry and Barnett designing a Bayesian model for clinical diagnosis [2], and Warner developing the first software to "time-share" and storage patient data with clinicians suggesting therapeutic approaches in medical decisions [3]. Clinical decision support system for animal settings, such as Zoos or Veterinaries hospital settings are almost inexistent, Caja et al., conducted a literature review on emerging developments in welfare biomarkers and smart support systems for dairy farm animals focusing on the relevance of the technology for farmers and the production of dairy. The authors concluded that the combination of multiple-data streaming from different systems still represents a major challenge for knowledge discovery in the dairy-animal industry [4]. Visoli et al present two algorithms for bovine traceability [5], Stevenson et al. presented the components of an animal health decision support system for enhancing food safety and decreasing infectious disease incursions, and animal productivity [6], and Jorgensen design a Bayesian framework to monitor and diagnose herds in animal production [7]. However, the design and development of decision support systems for clinical use by scientist, zoologists and veterinarians has been very limited if not existent. Sample-data synchronization controllers integrating signals from actuators, devices, sensors and applications in a Zoo setting targeting animal's health and welfare while under the care of humans represents the next step in animal conservation.

V. Methods

Biomedical devices, applications, services and interfaces require special rules and procedures, intimately related to the medical procedures, clinical environments, and animal welfare. Physiological monitors, for example, in general access 200 variables per frame, with one module per physiological variable. The technical for data acquisition such as: data frame sample time, synchronization, contextualization and transformation of data into information are only part of the challenges veterinarians face to make sense of animal data. On the other hand, the lack of medical device technology for animals is a reality and quite often, animal health care practitioners utilize human grade medical devices to assess and monitor their animal patients. The development of an ecosystem merging cross-platforms, cross-standards, and cross domains of services and applications utilizing an event-trigger controller as interoperable agent for hybrid systems and animal data contextualization tools will impact the high confidence medical systems by creating a standard for the communication architecture and by enabling a holistic approach that integrates context, actuators, users, and computers to provide inside in therapeutic decisions.

VI. Discussion & Conclusion

IoT systems are defined by the interaction between the physical and the digital environment with the ability to communicate efficiently translating data into information. The approach of an Interoperable IoT in the clinical setting aims to connect things, applications and services to improve operational efficiency, allocation of resources, assessment and diagnosis, outcome as well as optimize length of stay, reduce medical error, enhances patient experience and drug management. This methodology of knowledge-based framework may deliver tangible knowledge to different institutional levels, re-utilize clinical knowledge, and optimize the degree of new knowledge applied to conservation of endangered species facilitating the collaboration of zoologist, biologists and veterinarians.

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Sea turtle veterinary care and rehabilitation in the Maldives

C. Lomas, Olive Ridley Project

Abstract— **Sea turtles present a unique challenge to veterinarians working to diagnose, treat and rehabilitate individuals. These challenges are greater when working in remote environments with limited access to resources and advanced diagnostic technology.**

VII. Introduction

Sea turtles face many threats in the wild, the majority of which are caused by human activity [1]. Poaching, pollution, habitat loss and interactions with the fishing industry all have large impacts on populations [1][2]. This has led to the development of sea turtle rescue centers around the globe including the first veterinary center set up in Maldives by Olive Ridley project (ORP). Since opening in 2017, 143 sea turtles have been admitted to ORP rescue center in Maldives. 76% of sea turtle patients admitted to the center have wounds from ghost gear or plastic entanglement. Other common cases included buoyancy syndrome and boat strike injury.

The majority of cases seen had severe wounds from ghost gear entanglement, 47% required surgery to amputate one or more flippers. The physiology of marine turtles can make response to anesthesia highly varied and unpredictable.

VIII. Methods

Technology developed and utilized in other areas of veterinary medicine are often not applicable to marine turtles. Pulse oximetry to measure oxygen saturation of blood has technical limitations in turtles. Blood pressure measurement to assess cardiac function and anesthetic monitoring through standard oscillometric and doppler methods are of no use on turtles.

Gathering long term data on the success of released individuals is difficult. Current methods using satellite tracking devices have limitations and only transmit data for a finite period [3]. Advancements in technology would enable a more accurate assessment of long-term survival and success of individuals released after injury and rehabilitation.

IX. Discussion & Conclusion

Research and knowledge of sea turtle veterinary medicine has vastly improved through the work of rehabilitation centers and conservation efforts. Development of novel technologies could help efforts in conservation of endangered sea turtles.

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Challenges Facing Exotics and Wildlife Veterinarians: Monitoring

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Abstract— **Wildlife and exotic animals are challenging to appropriately monitor during general anesthesia. The specific challenges faced by the veterinarian include patient anatomy and physiology outside the "normal" range for many veterinary animals, safety of the veterinarian and/or the patient during handling as well as using monitoring equipment not designed for the animal's physiology. Improving safety for these patients undergoing general anesthesia is of paramount importance, as it directly relates to conservation of species.**

X. INTRODUCTION

Exotic animal species are becoming more common pets, and owners of these pets expect appropriate veterinary care for them. Local wildlife species are commonly brought to veterinarians after being found with traumatic injuries, and veterinarians are ethically obligated to provide care for these animals. General anesthesia or even sedation is associated with significantly more risk in small mammals compared to dogs and cats [1]. A large retrospective study compared the risk of sedation- or anesthetic-related death in several species and found the risk of death in dogs and cats to be 0.17% and 0.24%, respectively. The risk of death in rabbits, guinea pigs, hamsters, chinchillas and rats was found to be 1.39%, 3.80%, 3.66%, 3.29% and 2.01%, respectively. The risk of sedation- or anesthetic-related death is not documented in wildlife, but is likely even higher, and has recently been covered in the news when an Amur tiger died following general anesthesia to perform artificial insemination in March of 2021 [2]. Monitoring any animal during anesthesia can be difficult, but it is extremely challenging when the animal has significant physiologic or anatomic differences from that of companion animals or humans, for whom many pieces of monitoring equipment have been developed.

XI. METHODS

Animals are comprehensively monitored during general anesthesia: electrocardiogram (ECG), pulse oximetry, capnometry, blood pressure, temperature and hands-on techniques. Most of these modalities are challenging when used to monitor exotic animals or wildlife. Some animals are too small for the equipment to be safely placed on the animal. ECG clips to be placed on the animal's skin must often be adapted from conventional due to small patient size or skin texture [3]. Often the ECG will display complexes appropriately but is unable to display an accurate heart rate. Pulse oximeters have been validated in many mammalian species, but not in avian or reptile species; pulse oximeters often underestimate saturation in avian species [4].

Capnometry equipment adds dead space to the anesthetic breathing system, which may be significant for small exotic and wildlife animals [5]. Obtaining blood pressure measurements can be extremely challenging in small exotic and wildlife animals, and often only trends can be monitored due to poor accuracy in these animals [6]. Nonetheless, the use of monitoring equipment is essential for achieving good outcomes [7].

XII. DISCUSSION & CONCLUSION

Equipment for monitoring anesthetized exotic and wildlife animals is essential, yet the current state is not optimal. Veterinarians are well equipped to extrapolate information and adapt techniques when necessary to provide excellent quality of patient care, but this is a gap in technology. As exotic animals become more popular pets, as wildlife encounters with humans become more commonplace and as wildlife numbers continue to decline, good quality monitoring of these animals during general anesthesia becomes even more critical.

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The Toronto Zoo: Challenges and Opportunities of the Zoo of the Future

D. DeJong, J. Tracey, G. Mastromonaco, A. Lentini, The Toronto Zoo, Toronto, Canada

Abstract— **It takes a dedicated community of passionate activists to provide world class care for over 400 species and thousands of individual animals. Modern accredited Zoos are continuing to evolve to grow their contribution to wildlife conservation and improve animal welfare standards. At your Toronto Zoo, all of this takes place with the support and oversight of over a million guests, watching our team, the animals in our care and asking important questions on the future of Zoos and wildlife**

XIII. INTRODUCTION

As pressures on wild populations grow, the importance of building our understanding of zoonotic diseases, animal physiology and animal nutrition is becoming critical to ensure the long-term survival of many species. This, while also actively managing genetic diversity to ensure conservation initiatives and reintroduction programs are an option, are pushing good accredited Zoos in new directions. A critical part of this new direction is embracing the power of technology and questioning long standing assumptions on the best way to achieve our goals for wildlife.

XIV. DISCUSSION & CONCLUSION

The COVID-19 pandemic has added another layer of complexity to this journey. At the operational level, the need to protect the health of staff and animals has resulted in the addition of online digital screening, remote temperature scans and electronic keys to reduce contact and restrict access. The move to online learning and digital engagement have become powerful outreach tools as we look to live our mission, connecting people, animals and conservation science to fight extinction but are unable to host guests. These steps represent important progress and are critical as we challenge the status quo and evaluate new ways to operate safely and increase our reach and impact.

In order to ensure a brighter future for wildlife, we are seeing new collaborations between Zoos, researchers and leading technology thinkers. For your Toronto Zoo that means embracing artificial intelligence and machine learning to improve the monitoring of animal welfare. It includes working with new software and studbooks to track genetic diversity as well as the preservation of genetic material of endangered species of plants and animals as insurance populations. It also includes “the other AI”, artificial insemination, as we look to jumpstart species who are at risk.

More than a tourist destination, your Toronto Zoo is an important part of a global conservation movement, building understanding and being a voice for many species who can’t speak for themselves. Still wondering, just ask the Canadian populations of Blandings Turtles, Loggerhead Shrikes, Vancouver Island Marmots and Black-footed ferrets.