**CHAPTER 1**

**Introduction**

**1.1 Research Description**

Invertebrates are animals without a vertebral column also known as backbone or spine. They occur in great numbers living in both fresh and marine waters of lakes, swamps, marshes, rivers and oceans. Familiar examples are crabs, lobsters and their kin, snails, clams, octopuses and their kin, starfish etc. Many fresh and marine water invertebrates, however, including the copepods which constitute the secondary producers of the marine environments and a fundamental step in the trophodynamics of the oceans, are so tiny that they need special attention to collect and observe them. Thus, making them unnoticeable by casual visitors to aquatic habitats (Boehler, 2012). Many studies have been conducted in almost all aspects of copepods from its population, abundance, morphology, taxonomy, diet, diversity, ecology etc. but most of these studies employed conventional techniques especially in identification and classification where manual process is used and expertise is the primary requirement. To address this problem, scientists have started using Image processing as a tool for automatic identification of these species and Artificial Neural Networks for classification.



Figure 1: Copepods under a compound microscope

The digital image processing according to Gonzales and Woods refers to processing digital images by means of a digital computer. Furthermore, it is also a method to perform some operations on an image, in order to get an enhanced image or to extract some useful information from it. Nowadays, it is among rapidly growing technologies and act as a core research within engineering and computer science disciplines.

Image processing along with a system called Artificial Neural Network which is inspired by brain’s structure and function are commonly used in today’s researches. The ANN is considered a nonlinear statistical data modeling tool where the complex relationships between inputs and outputs are modeled or patterns are found (<https://www.investopedia.com/terms/a/artificial-neural-networks-ann.asp>). Many advancements in science and technology including biology, computer vision, speech recognition, machine translation, social network filtering, video games, medical diagnosis and artificial intelligence esp. in robotics use this model to perform specific tasks such as clustering, classification, pattern recognition, etc.(Gill, 2017).

**1.4 Background of the Study**

**1.4.1 Importance of studying copepods**

Copepods are microscopic crustaceans which ranges 200μm to 2mm in total length. They can be found in a large number approximately 60,000 individuals per cubic meter of water. Studying the community structure and abundance of the copepods in relation to their environment is important to evaluate their contribution to mangrove trophodynamics and coastal fisheries. They act as a linking factor between phytoplankton which are the primary producers of the aquatic environments and main food of the copepods and organisms of higher trophic level. They also act as a bioindicator for changes in water quality because their distribution and abundance can be affected by both abiotic and biotic factors such as salinity, temperature, food quantity and quality. Thus, copepods are one of most studied species in both marine and freshwater ecosystem (Leow, 2015). The routine in identification of copepods is very technical, needs taxonomical expertise to do, and takes so much time and effort (Leow, 2015). Hence, a need to develop an advanced method using new technologies today to automate the identification and classification of these samples.

**1.4.2 The Conventional way of Identification and Classification of Copepods**

The identification and classification of copepods which is summarized as: Collection from sampling sites, Preservation, Sorting, Examination and preparation which requires information of their morphology can be very time consuming and may require taxonomic expertise which is not readily available for undergraduate students and even some graduate biologist which does not specialize in copepods. Specific requirements for identification also include the Body shape to characterize the genera and Appendages such as fifth legs for species level. Thus, image processing tools of copepods are very useful for error-less digital recognition and may save up time and energy.

**1.4.3 Latest Advancement in Copepod Research**

Although there is an existing technique such as ZOOSCAN digital imaging system which uses image processing and yields semi-automatic recognition system (Grosjean et. al, 2004) for zooplankton, copepods were only covered in a few categories from the entire zooplankton community (Plourde et. al, 2008). Another technique which uses diffraction patterns as a tool for identification was also conducted by various researchers such as Zavala-Hamz et. al in 1996, Castro-Longoria et. al in 2001, Alvarez-Borrego et. al in 2001, and Castro-Longoria et. al in 2003 but it only caters calanoid copepods. The latest advancement in copepod recognition is in 2015 where Lee Kien Leow and his colleagues used image processing and artificial neural network to produce a computer software where the automatic recognition takes place of eight species of copepods but his technique uses only the conventional square grid lattice in image sampling using MATLAB’s Image processing toolbox R2013a.

**1.4.4 Neural Network for copepod Classification**

Classification methods for image identification systems have been used such as neural network, structural, fuzzy, and transform based techniques for many biological specimens but not with copepods. Artificial Neural Networks have shown promising results in classifying various specimens of insects (Wang et. al, 2012), dinoflagellates by Culverhouse in 1996, metazoans and protozoans by Ginoris et. al in 2007, and many more.

**1.5 Statement of the Problem**

The current problem that Biologists face in copepod research is the conventional way of identification. It would take a lot of time and effort to identify and classify species of copepods without expertise.

**1.6 Research Objectives**

**1.6.1 General Objectives:**

The study aims to utilize image processing techniques in recognition and classification of a copepod sample down to species level.

**1.6.2 Specific Objectives:**

1. Design an application which caters automatic identification of copepods down to species level using image processing.

2. Use ANN algorithm as a tool for classifying the copepods.

4. Use performance evaluation schemes to evaluate the system and compare manual identification versus an automated one.

**1.7 Scope and Limitations of the Research**

The research will focus in developing an application which will identify the copepod species for the users. The number of copepod species will limit based on the copepod species used in previous studies which is Eight species for efficient system evaluation. The system will utilize OpenCV toolbox for image processing and a Convolutional Neural Network using Tensorflow framework.

**1.8 Significances of the Study**

This study will help transition biologists from manual identification to automated process. It will also lessen the workload for any researchers and students which currently studies copepod.

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