Solution to Waste Management using Computer Vision

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Abstract: *The invention of Computer Vision gives its way to new possibilities and scope of development. This application, with its fundamental principles enhances the feature detection and provides in depth analysis on any problem, waste management, being one of them. The three levels of Earth: land, air, and water bodies have been damaged due to human intervention over the last few decades. This technology helps to detect the waste, and to bring awareness of the issue(s) in order to create a more habitable environment. Computer Vision also promotes to differentiate between the biodegradable material and wastes to the non-biodegradable ones. This up brings a practice of recycle, reuse, and reduce of the overall ecosystem and its practice of living.*

Keywords: Computer Vision, Debris, Waste Management, Land, Air, Ocean Bodies, Environment, Ecosystem

1. Thesis

Environmental debris has been a big problem and moreover it continues to be, and this causes damage to the planet. Various methods nowadays cope up to help in the participation of eco-friendly environment, thus trying to create a sustainable life. With emerging technologies such as Computer Vision, it helps to solve the major environmental problems by removing the wastage from the non-wastage from land, water bodies, and outer atmosphere.

2. Introduction

Using Computer Vision can greatly help in reducing the biological damage being done to the planet. By applications such as scanning and image recognition it can find various components in the ecosystem which are known as debris. This technology helps to reduce the wastage on the planet and exhibit the practice of reusable items, in which, brings a healthy scope to the environment and people. It endures the motivation to reduce, reuse, and recycle.

A. *World Problems*
The present-day world faces many challenges when it comes to the sector of environmental effect, especially in the notion of differentiating between biodegradable and nonbiodegradable objects. The common challenges which are brought up today are land, air, and water problems. Problems include pollution, greenhouse effect, contamination of water, and destroying natural habitats.

1. Pollution:
The effect of pollution greatly affects Earth by destroying its natural environment by trapping gases and chemical compositions in its' surface. This brings an unstable threat to all life by contaminating its natural habitats and brings an uprise to health problems.

2. Greenhouse Effect:
A man-made problem from the creation of many technologies like factories, power plants, and industries affects the natural behavior or stable environmental practices and provokes exposure to the unhealthy lifestyle by bringing in challenges. The challenges include heating up the planet which causes abnormal climate changes and weather patterns. This disrupts the ecosystem and its natural approach from human activities.

3. Contamination of Water:
Practices of dumping waste material, creation of sewage, oil spills, and radioactive materials have been slowly changing the water bodies. This ill practice gives its exposure by contaminating the water and affecting all life within the land and sea. Due to this, health problems tend to arise in the aquatic and marine life thus, it affects the food chain.

3. What is Debris

Wastes are materials that have been used, deemed as worthless, unwanted products, and defective that have been disposed after usage. Waste management has been an ongoing problem for many decades. The estimates show that waste management costs will increase to 375.5 billion dollars annually in the upcoming years, mostly by 2025. The many examples of waste products are urban, industrial, biomedical, and e-waste. These waste products further classify into solid and liquid types. [2]

Types of Debris:
1) Land Problems
The oldest form of waste treatment started on land, thus ranging from landfills to incineration. People have been dumping all types of waste on land and this affects many areas as well as in the environment.

A. *Landfills*
Landfills are the biggest human creation that pollutes the planet's air, ocean, and food supplies. It is the root cause of the global climate change. These landfills together are combined into many types of debris such as, municipal waste, medical waste, hazardous waste, and special waste. Another concern with landfills are that many facilities are located near public areas such as playgrounds, parking lots, and sport centers which lead to leakages, terrible odor, decreased property value, loss of habitable life, and high traffic.

B. *Incineration*
Waste incineration is another contributing problem to our planet where burning various wastes releases toxic

chemicals such as Mercury, Lead, and additional chemicals into our air. Due to this, it produces toxic ash and toxic chemicals that lay in the air and therefore damages the workers' health and the nearby neighborhoods. [3]

2) Air Problems

Air pollution has been corrupting the general health as well as disrupting the major ecosystems in our environment. The cause and effects of air pollution are global warming, acid rain, and ozone depletion.

A. Acid Rain

Acid rain is caused when Sulphur dioxide and nitrogen oxide is reacted with the water in the atmosphere and form a substance called acid rain. This formation has a pH value of 3-6, which damages the environment. The effects are, it causes respiratory and skin disorders, declines plant growth by damaging its roots, damages aquatic life by entering the water bodies, and causes destruction to monuments and buildings. [4]

B. Global Warming

The main concern in our world today is global warming. This affects the climate life in all regions of the planet, from plants, animals to agriculture and food production. Global warming is caused by the process of trapping gases in the Earth's atmosphere which causes the planet to heat up. This is known as the greenhouse effect. According to many scientists, the average global temperature has increased by 5 degrees compared to the last 800,000 years. The result of global warming causes disturbing weather patterns, melting of ice caps, and rising sea levels. This all the affects the habitats of all life on Earth. [5]

C. Ozone Depletion

Earth is protected by the ozone layer which lives outside of our atmosphere, which is now being depleted by manmade compounds such as chlorofluorocarbons. The ozone layer protects the planet by blocking ultraviolet radiation and harmful gamma radiation that passes through the void outside the planet. Over the past few years, ozone holes have been discovered in the different regions of the globe, where ultraviolet radiation has been surfacing inside the atmosphere. This causes human health problems like skin cancer, weakening the immune system, and accelerated aging. The damage done to the environment is slowing the minimal growth of plants due to UV light. This radiation damages the ecosystem by affecting the weakest link such as planktons. Industrial materials such as plastic, wood, rubber, and fabric are highly damaged by ultraviolet radiation are also affected. [6]

3) Water Bodies

The activities of human intervention have caused high amount of pollution in these large bodies of water. These activities include: dumping debris, oil spills, and sewage.

A. Dumping

The activity of dumping involves debris and other unhealthy materials to the ocean waters which cause high amounts of toxicity which contaminates it. Objects often lay floating on top of the surfaces of these bodies of water giving a malign effect. Industrial waste has caused much pollution in these water bodies by the activity of dumping, thus affecting the marine life. Marine animals and other sea life have been greatly affected causing a disturbance in the ecosystem. Objects such as plastics have been damaging these animals' digestive system by absorbing all the chemicals that has been bonded with the plastic waste. This directly attacks the different levels of the food chain. [7]

B. Sewage

Gases like Nitrous oxide, carbon dioxide, and Methane concentration have been releasing into our atmosphere by sewage waste. This has also been one of the main causes and effects for greenhouse gases. Chemicals like these are absorbed into the sewages and on a daily basis and give out unhealthy releases which contaminates the air as well as the oceans. [8] Due to these chemicals as well as other debris being found in sewages, they are sent in flows of water in which some get mixed in with the large bodies of water, thus giving an ill effect to the aquatic life. Diseases such as pink eye, stomach aches, and respiratory infections can be provoked not only to marine life but also human life when in direct contact. The sewage waste has been affecting clean water and high salinity by the concentration of CH_4. [9]

C. Oil Spills

The impact of oil spills has been ruining the infrastructure and the economy as well as the marine life, plants, and animals on land and sea. Oil spills are caused by people making errors on who are on the duty of being in charge of oil. Often ships carry large abundance of oil across the globe and majority of the time oil falls into the sea, causing an unhealthy marine environment. The oil in the water bodies can be noticed due to the thin frame of color which spreads over the water and thus changes the chemical composition as well as the purity of the water. Crude oil evaporates at least 30% after spillage, which affects the atmosphere by climate change, such change are in wind patterns and tropical sun. [10]

The numerous waste products on our planet ranging from land to ocean bodies and above have been deemed to disturb the healthy environment and its ecosystems. Wastes has been a major problem and yet to continue, however, with the practice of reusing waste materials have helped to slow down the process of waste management. Evolving technologies such as Computer Vision plays a role in this area, by differentiating the reusable to non-reusable waste. With its 3-Dimensional image sensing functions, it helps to increase the practice of reusability.

4. Computer Vision

Computer Vision is a type of technology that uses computational models from a human visual system that build an autonomous system, which can perform tasks that the human visual system cannot. Many tasks are extraction of 2-Dimensional temporal data to create 3-Dimensional temporal information. Data is extracted from one or more cameras which can provide an understanding of dynamic scenes. Computer Vision can enhance the perspective by allowing itself to build more parameters of vision sensing which grants futuristic and in-depth information. [11]

For example, The Hubble space telescope uses Computer Vision to analyze different segments in space. It uses different filters of vision such as infrared, x-ray, and gamma ray, which can give a provide a different perspective of the universe. So far, it gave us the location of different galaxies and new information about different planets. [12]

History [13]

The history of Computer Vision was created by Larry Roberts, who came up with a thesis in 1960 at MIT discussing the ways of extracting 3 dimensional information from 2 dimensional perspectives. Later on, a major breakthrough surfaced by David Marr in MIT, in 1978, who made an approach known as "Bottom-Up Approach" to scene understanding. This idea, was performed to allow real life images in different situations to be visualized by a computers point of perception. The computer allowed itself to create a sketch of the scenic images displayed and enabled itself to put forth an advancement of visualization which can give back more information when required. A new paradigm was created by Yiannis Aloimonos from the University of Maryland, calling it the "Proposive Vision". This technique uses 3 dimensional motion of an object, which is to predict an object moving towards you and an object moving away from you. Computer Vision came a long way in the history of technologies which merged into new related fields which include image processing, photogrammetry, and determining an objects pose in 3 Dimensional sphere.

Applications [14]

The applications that Computer Vision can do are:

- Image Formation: *Using geometric primitives and transformation from a digital camera.*
- Image Processing: *Taking an image and processing by the color, pixel value, histogram, and adjusting the tone of the image.*
- Feature Detection and Matching: *This allows to detect the key elements, lines, and edges of an image.*
- Feature Based Alignment: *By using 2D and 3D features of an image, alignment is done to the image. Most algorithms pose as an application known as Augmented Reality.*
- Image Stitching: *The process of merging different perspectives and exposures of an image to blend into one. Also, combining a variety of images and their perspectives into a 3 Dimensional model.*
- 3D Reconstruction: *This takes the three coordinate axis of an image from two horizontal vanishing points to create a new view of 3D construction.*
- Computational Photography: *This transforms an image into a high dynamic image (HDR), increases resolution and removes the blur of an image.*
- Image Based Rendering: *This analyzes images that have depth in different light fields that are held in different environment(s).*

In the modern day approach of technology, Computer Vision continues to become advanced as new formalities come into place. It is vital technology that has been able to help solve many challenges and become an important part to our change of development.

5. Approach to Problems

The use of Computer Vision helps with the classification process of detecting waste materials of different entities through means of reusable items to non-reusable items. The classification takes place in land, air, and ocean bodies. With the approach of Computer Vision and its 3-Dimensional image processing, feature detection and matching, it helps in the procedure of accurately analyzing and categorizing different waste material based on their customs.

A. CV on Land

The application of Computer Vision using its many functions such as, image recognition, classification, have helped sorting different types of wastes on streets. By using a high-resolution camera, in built with computer vision, mounted on any vehicle can help detect many wastes that include newspapers, plastic bottles, leaves, etc. The way computer vision analyzes a waste product by having a classification image that uses it to detect other products and materials. The classification images come from its own dataset of images taken from high resolution camera that clearly points out its different edges and vectors.

This technology predicts by using regression networks from the combination of classification images it helps the detection of waste material. [15] Another benefit for using Computer Vision would be recycling and reusing valuable materials such as, metallic materials and nonbiodegradable items. Using an application called hyperspectral image analysis can give a high accuracy to identify, separate, and sort materials from valuable resources to hazardous waste. The results of using hyperspectral image analysis according to an experiment, gave an accuracy of 98% to identify and sort the following materials, like: copper, aluminum, stainless steel, brass, and led. [16]

Computer Vision in land and its common surroundings has been able to detect the different particles that lie in the objects and differentiate among them. The use of recycle and reusability has made it as a standard practice today and with this technology, image analysis and segmentation are made easier. Detection of different materials such as non-biodegradable objects that are made into an object of reusability is an application in which this technology implements. Computer Vision, when dealing with the wastage of land, reduces the unhealthy practices and promotes more awareness.

B. CV in Air

Waste is one of the leading attributes that causes climate change and global warming. The pollution from the waste has been causing multiple fluctuations in the seasons that has been damaging the air quality, visibility, and inducing asthma to the public health. The applications of Computer Vision can scan the atmosphere to get depths of data to identify sources of visibility and invisibility of pollution. A recent report was made to extract images from China and the US, which stated that the data in the images show time, date, geographic information in various weather conditions, all to predict an atmospheric particle matter. These reports indicate the particle matter of 2.5, which results in harmful health effects such as shortness of breath, eye, nose, and

throat irritation. Another public health risk would be cardiovascular respiratory diseases.

With the help of Computer Vision, large amounts of data were able to be retained to predict the upcoming forecast that can damage the conglomeration. The procedure of receiving the data can be done by using image processing algorithm to predict the pm index. The algorithm follows the various steps, by having two types of data by training and predicting.

Within these two types of data, the inner procedure follows:

- Training Images
- Regions of Interest Selection
- Feature Extraction
- Regression Model
- Prediction Process

The important step in this algorithm is the feature extraction model, where it helps to determine the attenuation of the scene radiance. This information describes the color, intensity, haziness, and visibility of image(s), that tells us the amount of polluted air within the image. This application can help with the detection of problems in air pollution and alert general public health to be aware of its setbacks. This technology helps to retain the atmospheric value as well as predict future forecast, which helps in analyzing of the planet's behavior and patterns. [17]

C. CV in Water Bodies

According to the World Health Organization, 80% of all public-health related diseases come under the poor treatment of water quality that leads to waste water. Wastewater has a been has ongoing problem for the past few years, and the traditional ways of water testing is a tedious process under laboratories, where its time consuming and takes highly skilled practitioners to perform the water quality tests, given if the many regulations and laws are permitted to do so under the strict enclosed environment from many corporate companies.

The use of computer vision can enhance the detection and monitoring the wastewater by using the its sub-application image analysis. It can detect the level of contamination and the different contaminants within the water that was a result of human activities. There are four periods in which image analysis work into, they are:

- Image Acquisition: The first stage of any vision system, being able to retrieve an image from a source that is hardware based to process. Without Image Acquisition, there displays no image hence no processing.
- Image Preprocessing: The second stage of vision system safeguards the image from any distortions, and enhances the image to be clean by adjusting its brightness. This in turn, can be easily viewed by the machine.
- Image Segmentation: This is the process of dividing a digital image into multiple segments. The results of this feature are to simplify the image so it can represent in a more meaningful way to analyze.

- Image Analysis: This is the final stage of any vision system and the target is to withdraw relevant information from a digital image. Image analysis dispenses to numerical outputs.

Using the various features of Computer Vision, this enables to provide an input to the purification of water bodies and the waste management control on which determines the value of the water. These features help in enrollment of scanning and detection of impure water and its whereabouts, thus helping to understand how to keep the environment clean. This application monitors and treats the sewage level in water quality from the images of sewage water. [18] Another way to detect waste in water is using deep learning-based machines. Training a computer vision to find marine debris, such as common items like plastic, metals, and any other type of waste that pollutes the water can be detected in real time. Many detectors were made using a graphical processor such as NVIDIA GTX 1080 graphics card that were put together in a scalable link interface (SLI) and computing processing chips where from INTEL. The class detection of data is divided into three groups, plastic; containing all marine debris, ROV; manmade objects, and biological substances; include organic life. The results of this experiment show that in the near-coming future using computer vision to detect trash underwater is very possible. Many objects that pollute the areas under the sea can be disposed by using Computer Vision, which can save the marine life and keep the planet clean. [19]

Technologies have helped in playing a role in environmental sectors by providing the right equipment to filter out the different types of debris and how to overcome the problems faced in the world. In particular, with the help of Computer Vision, it enables itself to portray image analysis and recognition with the help of its 3-Dimensional features to overcome the problems we have today. Computer Vision is an act that allows it to enable to visualize what a human being can see and observe from their eyes. It gives itself the ability to form 2-D images of real-life occurrences into 3D perspectives of those same situations. It gives more of an input and output analysis than what the human eye does. It goes into deeper aspect of an occurrence and can expect future outcomes from its experiences and information it receives.

6. Conclusion

In this paper, we have evaluated that using Computer Vision leads to detection of the wastage of debris on Earth. The application of Computer Vision is able to detect the three levels on the planet, which includes, land, air, and water bodies. With this technology, the scope of waste management can be signified under certain means of discovery. Reusability and recycling are such activities that are promoted with the usage of this application, driving to educate the means of biodegradable substances to non-biodegradable substances, helping to improve the overall damaging factors in the environment. Using the traditional ways of detecting waste management have cost the economy and general health of the public to put themselves under risk. Computer Vision can ease the process of detection and give more input to the problem and its current situations. With

more information and in-depth analysis on waste control and its diverse mediums, this changes the primary way of doing things.

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