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Research Article

ARTIFICIAL INTELLIGENCE FOR IDENTIFICATION OF POLLUTION PUNCTUAL SOURCES IN ARROYO MORENO, VERACRUZ, MEXICO

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Abstract

The mangrove swamp of the Arroyo Moreno State Natural Reserve is of great ecological importance due to its function as a protection and containment barrier against the effect of storms and hurricanes. It is a refuge for wild flora and fauna. The basin of the Arroyo Moreno river crosses said nature reserve and the Puente Moreno housing development. There is a pollution problem in the Arroyo Moreno river basin due to the discharge of wastewater without prior treatment, mostly from the subdivision in question. This, alters the quality of the tributary. The uneven terrain of the stream bank makes it difficult to travel and represents an inconvenience to visually identify the Pollution Punctual Sources (PPS). Unmanned Aerial Vehicles (UAVs) were used to take aerial photographs of the river basin. Artificial Intelligence (AI) was trained on 160 images using the IBM® Watson Studio Visual Recognition platform. After training, the UAV was flown to detect PPS. A total of 821 photographs of the Arroyo Moreno basin were captured. Fifteen PPSs were identified in subsequent flights across the river basin with similarity percentages of up to 92%. The PPSs were georeferenced and represented using the ArGis 10.3. A map with the PPS detected by AI was obtained. The proposed methodology will serve as a basis for the development of other applications in the environmental area. This information is a support to river recovery. The aim of this research was to identify the PPSs in the Arroyo Moreno river using AI.

Keywords: Arroyo Moreno, Artificial intelligence, mangrove swamp, Pollution Punctual Sources, Unmanned Aerial Vehicles.

INTRODUCTION

Currently, the scarcity of water is caused by the misuse of it, the increase in its demand and the growing degradation of its quality, preventing its use and consumption. This makes the water problem a priority issue [1]. In turn, water pollution is defined as "an alteration produced by man in the physical, chemical and biological integrity of water" [2]. In that order of ideas, anthropogenic pollution in water is a problem that has been produced for a long time, due to the fact that waste from human activities is dumped into lakes, rivers, lagoons or others, modifying its natural quality [3]. There are two types of pollution that affect water supply sources: punctual and diffuse. PPS are easily identifiable, for example; in pipes, ditches, canals, tunnels, ducts, wells, discrete cracks, containers, rolling stock, intensive livestock farming, among others [4-6]. Diffuse sources of pollution are complex to identify, since they are related to agricultural and industrial activities [2, 7, 8]. In this context, Morlans-López [9]mentioned some consequences that pollution sources can bring, such as eutrophication and salinization of water bodies, increased concentration of heavy metals, presence of pathogens and toxic microorganisms in water bodies. Commonly, to assess pollution in a body of water, it must be sampled and subsequently identify the presence of contaminants. However, the identification of PPSs is sometimes complex due to the availability of access roads, either due to the presence of vegetation or being under private property, among others [10, 11]. Likewise, the proximity of human settlements to bodies of water has caused pollution problems, since in some cases wastewater is dumped into rivers without being treated. This puts at risk the quality of the water, the biological cycles of the endemic fauna and flora, and the health of the inhabitants of the area [12, 13]. Given these conditions, there has been a shortage of water resources, increased demand and growing degradation of its quality, limiting its use and consumption. This being a priority problem [1, 14, 15]. On the other hand, Artificial Intelligence (AI), according to Benítez, Escudero [16], is defined as "an academic discipline related to the theory of computation, whose objective is to emulate sensory perception processes (vision, hearing, among others) and their consequent pattern recognition processes, so that their usual applications are data processing and system identification. AI is a new technology that has been applied in solving society's problems. Two cases of the aforementioned are the works “Survey flooded neighborhoods to identify survivors on rooftops and detect rescue boats” [17]and “Watson on the Farm: Using Cloud-Based Artificial Intelligence to Identify Early Indicators of Water Stress” [18]. On the other hand, the mangrove is a habitat that forms a transition system between marine and terrestrial environments. For this reason, they constitute a support for a great biological diversity and with ecological processes typical of such environments. A mangrove forest develops in the Arroyo Moreno river basin. This is a protected area called Arroyo Moreno State Natural Reserve. The mangrove that grows there is important for two aspects; the first is of the riparian type and is adapted to brackish water;

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this is due to the entry of seawater into the reserve. Second, it is a natural "lung" that absorbs pollutants from the water and transforms them into oxygen, because it is surrounded by multiple urban areas. In 2008, the Arroyo Moreno mangrove was considered an ecological reserve. However, it continues to be contaminated by the urbanization that surrounds the place, especially by the drainage of the subdivisions that flow into the river [19].Therefore, the aim of this research was to identify the PPSs in Arroyo Moreno, Veracruz, Mexico; using AI with an UAV (drone).

MATERIALS AND METHODS

The study area was the basin of the Arroyo Moreno, whose channel crosses the Arroyo Moreno State Natural Reserve. It is located at coordinates 19° 05' and 19° 08' N and 96° 06' and 96° 09' W. The climate of the region is warm sub-humid (Aw2), with an average annual temperature of 22°C and the temperature of the coldest month is 18°C. The precipitation of the driest month ranges between 0 and 60 mm; and the percentage of winter rainfall from 5% to 10.2% of the annual total [20]. Arroyo Moreno is located near the central coastal zone of the State, in the municipalities of Boca del Río and Medellín de Bravo, Veracruz, Mexico. It borders the Miguel Alemán, Plan de Ayala and UGOCEP neighborhoods, to the east with the La Joya subdivision, El Morro neighborhood, Graciano Sánchez and to the south with the La Tampiquera subdivision.

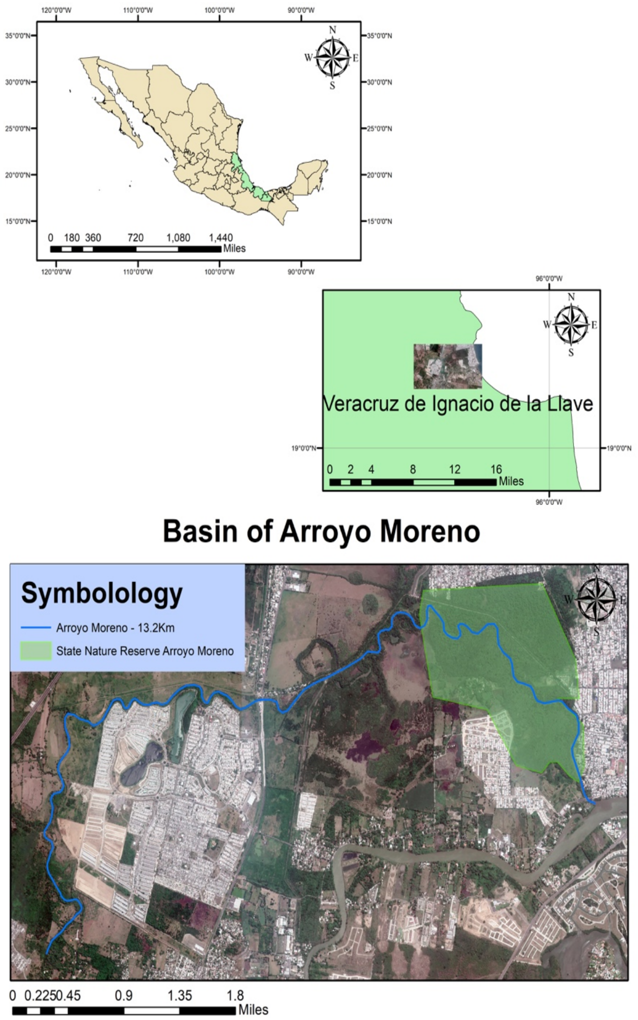

Figure 1. Macro location of the Arroyo Moreno basin

Two UAVs were used to take the images of the AI training and identify the PPSs, with which a total of 821 photographs of the Arroyo Moreno basin were captured (Table 1).

Table 1. Characteristics of the drones used in the project [21]

MavicMini _	Mavic Air 2
Drone Specifications: • Takeoff Weight: 249g • Max time flight: 30 minutes • Video Transfer: 4Km Camera Specifications: • Sensor: 1/2.3" CMOS; Effective Pixels: 12 MP. • Still Image Size: 4:3: 4000×3000; 16:9: 4000×2250 • Video resolution: 2.7K. Images captured with the drone: • 610 Total images: 821	Drone Specifications: • Take-off weight: 570g • Max time flight: 33 minutes • Video Transfer: 10Km Camera Specifications: • Sensor: 1/2.3" CMOS; Effective pixels: 12 MP and 48 MP. • Photo size: 48 MP 8000×6000 pixels • Video resolution: 4K Ultra HD. Images captured with the drone: • 211

To implement the IBM® Watson Studio Visual Recognition AI, training was performed with positive and false positive images. The positives in this case were the PPS previously identified, as shown in Figure 2. These can be taken in the study area or from any other place that presents these characteristics.

Figure 2. Artificial intelligence training. (Left) Positive image. (Right) False positive

False positives are images that might appear to be true PPS but are not. These false positives can be boats, trees, or other objects that can confuse the AI (Figure 2). For optimal training, it is recommended that the proportion of positives and false positives be at least 50/50. The more images provided, the higher the accuracy up to a certain limit. However, when you have a huge number of images, say more than 1000, the improvement in identification will be minimal and irrelevant. Due to the aforementioned, training the AI in a range of 150 to 200 images in total, provides a good balance in the number of images with respect to the accuracy of the results [22].

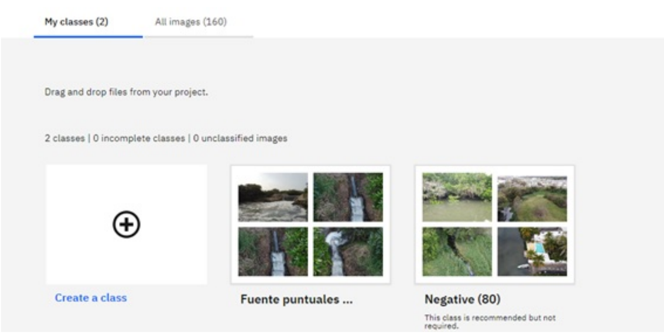

Figure 3. IBM® WatsonStudio® Visual Recognition AI training on PPS identification

Figure 3 shows a screenshot of IBM® WatsonStudio® Visual Recognition training, in which a total of 160 images were used: 80 positives (PPS) and 80 false positives (images that could be mistaken for a source of pollution). pollution spot).

Figure 4 is an example of PPS identified by AI, capture in a drone flight. The results of the AI can be observed, as shown in Figure 5, where the percentage of success is assigned with respect to the positive or negative identification of the PPS. In the "Test" tab, the "Threshold" bar was set to 0.070 to filter out all images that had a lower score, and any image that had a higher score was considered a PPS.

Figure 4. A PPS detected in Arroyo Moreno in a drone flight in the Arroyo Moreno basin. Taken by aerial photograph

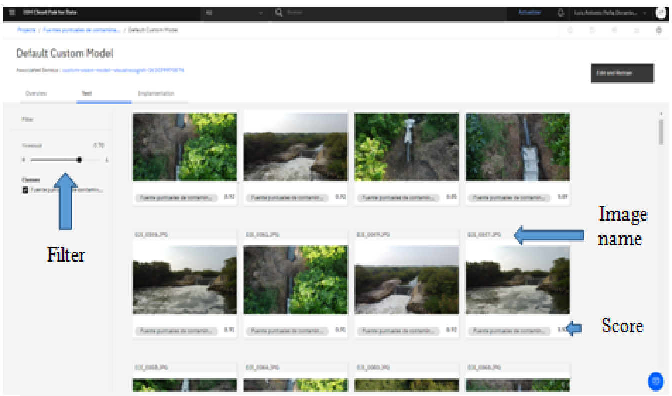

Figure 5. Identification of PPS using the AI, IBM® WatsonStudio® Visual Recognition

In total, 83 images were identified; which, due to the score obtained from the IA, were considered as PPS. Subsequently, the "Exit Pilot" program was used to extract the metadata of the selected photographs. The extracted information corresponded to the geographical coordinates of the place where the photographs were taken with the drone, as shown in Figure 6.

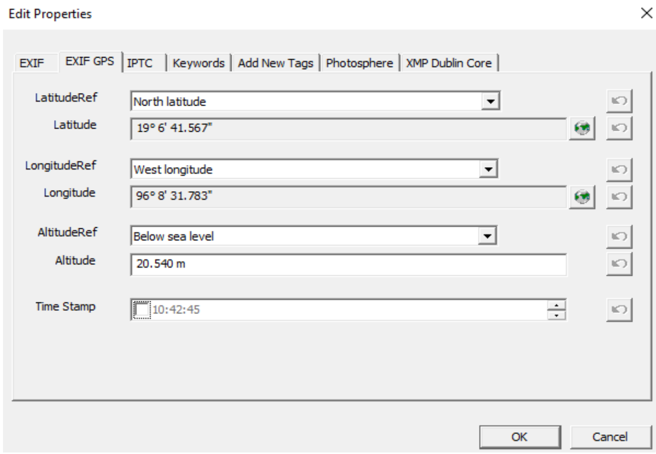

Figure 6. Extraction of the geographical coordinates of the identified PPS

Subsequently, the coordinates of the images were captured where the PPSs were identified in the "Google Earth Pro" program. To reduce the number of points detected by the AI, the main location of the site was placed taking into account the perspective and the satellite image of the place to locate the point source of pollution with an accuracy of ±10 m. The above, because several of the images belonged to the same site, but taken from different positions, as shown in Figure 7.

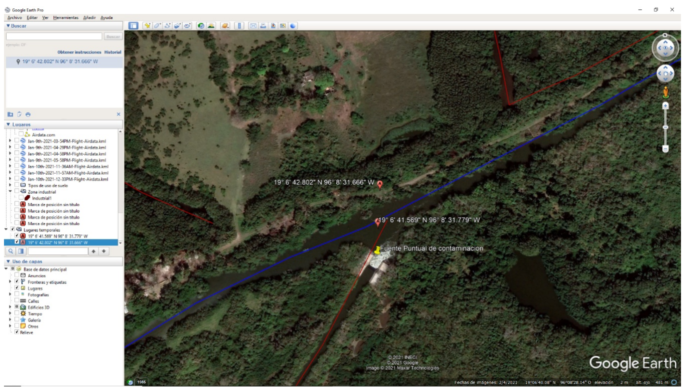

Figure 7. Reduction of the number of points detected by the AI to obtain the locations of the PPS in Arroyo Moreno

Finally, the information was captured in a Geographic Information System (GIS), to generate a map with the locations of the PPSs detected in the study area.

RESULTS

610 images were captured, in inaccessible places, with the DJI Mavic mini drone, with the following characteristics: 16:9: 4000×2250 pixels and 4:3: 4000×3000 pixels using the camera included in this model (1/2.3 " CMOS; Effective Pixels: 12 MP). With the DJI Mavic Air 2 drone, 211 images of 48 MP: 80000x6000 were captured by the included camera (Sensor: 1/2.3" CMOS; Effective Pixels: 12 MP and 48 PM). With the AI, previously trained, the positive and false positive images, the photographs captured on the tour were analyzed quickly and efficiently. As a result, possible PPS were obtained with an associated similarity percentage in a range between 0 and 1; where 1 represents 100%. Consecutively, the results of the AI were analyzed, where the percentage of success was obtained with respect to the positive or negative identification of the PPS. The results shown in the photographs as positive, that is, PPS, were close to 1.0; while the photographs where there are no pollution sources tended to 0.00.

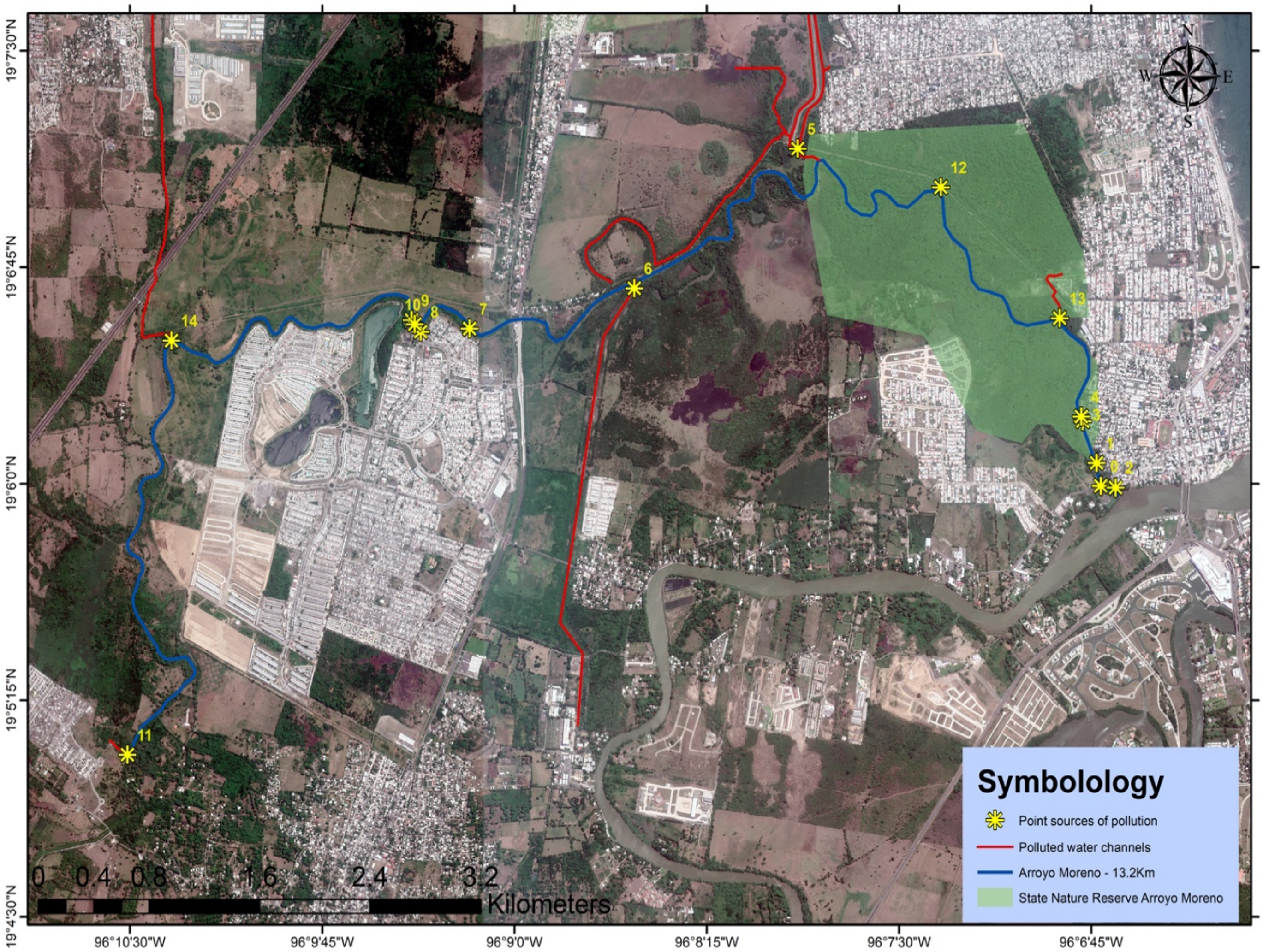

Figure 7. Identification of PPS in Arroyo Moreno using AI from IBM® Watson Studio Visual Recognition

After the identification process of the PPSs with the AI, the images with greater precision were selected and the meta data of the georeferenced contained in the files was extracted. Finally, with the georeferenced obtained from the images, a database was generated that served to geo-position the sites identified as PPS on a map of the study area (Figure 7). For the above, the ArcGIS V10.3 software was used.

The results of geographical coordinates of the point PPS are shown in Table 2.

Table 2. Geographical coordinates of the PPS of in Arroyo Moreno

FID	Name	POINT_X	POINT_Y
0	Pollution Punctual Source	-96.11187217	19.09988247
1	Pollution Punctual Source	-96.11213749	19.10120904
2	Pollution Punctual Source	-96.11091025	19.09978633
3	Pollution Punctual Source	-96.11303828	19.10361645
4	Pollution Punctual Source	-96.1131294	19.1038894
5	Pollution Punctual Source	-96.13156665	19.11936154
6	Pollution Punctual Source	-96.14219144	19.11129818
7	Pollution Punctual Source	-96.15290376	19.10896289
8	Pollution Punctual Source	-96.15607771	19.10878959
9	Pollution Punctual Source	-96.15667744	19.10945805
10	Pollution Punctual Source	-96.15647283	19.10922005
11	Pollution Punctual Source	-96.17515409	19.08436126
12	Pollution Punctual Source	-96.12226649	19.11712551
13	Pollution Punctual Source	-96.11453764	19.10957147
14	Pollution Punctual Source	-96.17229683	19.10828045

Conclusion

An PPSs map of the study area was constructed. This methodological proposal can be used to locate possible PPSs in inaccessible places anywhere in the world. Likewise, the foundations are laid to have a tool that contributes to reducing pollution from anthropic origin. With the images obtained in this research work, that is, during the visits to the study site: walking, with the drone and by boat, it was possible to observe how the urban sprawl has gradually invaded the river, negatively modifying the place. The use of AI IBM® Watson Studio Visual Recognition extends its application to future research projects where image recognition is needed in the environmental area. With the results of this project, PPS information was generated that had not been considered and that will serve for later studies in the evaluation of the water quality of the Arroyo Moreno Protected Natural Reserve.

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REFERENCES

1. Fresta, P., Evaluación de peligrosidad de contaminación potencial del agua subterranea por fuentes puntuales. 2016.

2. Bravo-Inclán, L., et al., La importancia de la contaminación difusa en México y en el mundo. 2013.
3. García-Lemmo, R., et al., Dispersión de contaminantes en cuenca Tumaque entre Lara y Yaracuy en Venezuela. Ingeniería Hidraulica y Ambiental, 2014. 35(2): p. 79-93.
4. Dalmaso, M.G., D.E. Martínez, and E.E. Mariño, Contaminación por efluentes de la industria frigorífica: El caso del acuífero arenoso de General Pico. Hidrología Subterránea. Serie de Correlación Geológica, 1999. 13: p. 187-194.
5. Lima, L., et al., Evaluación preliminar del peligro de contaminación del agua subterránea a partir de fuentes puntuales en el Partido de General Pueyrredon, provincia de Buenos Aires. 2016.
6. Massone, H., et al., Inventario de fuentes puntuales de contaminación potencial del agua subterranea: caso de estudio Mar del Plata. 2016.
7. Carro-Mijangos, M.A., R. Villela-Gonzalez, and L.A. Bravo, ESTUDIO DE FUENTES DE CONTAMINACIÓN PUNTUAL Y DIFUSA EN LAS SUBCUENCAS DEL LAGO DE TUXPAN Y RÍO TOMATAL, IGUALA, GRO., MÉXICO. 2015.
8. Torres-García, L.A., Distribución espacio-temporal de la contaminación del agua del río chumbao andahuaylas, apurímac, Perú. 2011-2012. 2016.
9. Morlans-López, A., Contaminación difusa en acuíferos: estudio de caso en la comuna de Colina, Región Metropolitana. 2010.
10. Callasaca-Pacheco, R.A., Influencia De Fuentes Puntuales De Contaminación En La Calidad De Agua Del Rio Coata, En El Tramo Puente Maravillas Y Puente Coata, Puno 2018. 2020.
11. Torres-Beristáin, B., et al., Enfoque de cuenca para la identificación de fuentes de contaminación y evaluación de la calidad de un río, Veracruz, México. Revista internacional de contaminación ambiental, 2013. 29(3): p. 135-146.
12. Lafargue, T.A., Caracterización de algunas de las principales fuentes contaminantes de la bahía de Santiago de Cuba y sus consecuencias en el medio ambiente. Tecnología Química, 2008. 28(2): p. 79-89.
13. Pulido, M.d.P.A., et al., Indicadores microbiológicos de contaminación de las fuentes de agua. Nova, 2005. 3(4): p. 69-79.
14. Aguilar-Ibarra, A., et al., La contaminación del agua como una externalidad para la producción pesquera y acuícola. EN MÉXICO, 2006: p. 107.
15. Ruiz-Andrés, S., Evaluación de los niveles de metales pesados e hidrocarburos aromáticos policíclicos (HAPs) en aire ambiente en zonas afectadas por fuentes puntuales en Cantabria. 2014.
16. Benítez, R., et al., Inteligencia artificial avanzada. 2014: Editorial UOC.
17. Walicki, J. Survey flooded neighborhoods to identify survivors on rooftops and detect rescue boats. 2019; Use drone aerial images, Watson Studio, and Watson Visual Recognition to survey damage]. Available from: https://developer.ibm.com/tutorials/use-drones-after-floods-to-help-survivors-watson-visual-recognition/.
18. Freeman, D., et al., Watson on the Farm: Using Cloud-Based Artificial Intelligence to Identify Early Indicators of Water Stress. Remote Sensing, 2019. 11(22): p. 2645.
19. Castillo, A., et al., Arroyo Moreno: Un manglar en la ciudad. 2016.
20. García-Villar, A.M., J. Montoya-Mendoza, and R. Chávez-López, HISTORICAL APPROACH OF THE FISH SPECIES COMPOSITION IN ARROYO MORENO, VERACRUZ, MEXICO. BIOCYT Biología Ciencia y Tecnología, 2019. 12(45-48).
21. DJI, MAVIC SERIES. 2021.
22. Gong, K. Construya con los consejos de Watson: Mejores prácticas para utilizar clasificadores personalizados en Watson Visual Recognition. 2017; Available from: https://www.ibm.com/developerworks/ssa/library/cc-build-with-watson-tips-best-practices-custom-classifiers-visual-recognition/index.html.

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