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**THE EMERGING METHOD OF DOMESTIC PLASTIC WASTE
TREATMENT IN HANGZHOU: AI APPLICATION**

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ABSTRACT

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<p>This thesis is about the new-stage combination with traditional plastic waste methods and artificial intelligence. Even though the society already has traditional methods to treat plastic waste, the plastic still occupies a great proportion of the solid waste. This thesis will analysis the features of the artificial intelligence, and assume the application in the treatment steps. There are three main traditional methods. All of them have their disadvantages. Artificial intelligence can achieve the progress on many levels. Besides, have prospects and potential in the future. The final aim is meeting the waste treatment in high-quality.</p>		

Key words: combination, effective, emerging technology

CONCEPT DEFINITIONS

AI : Artificial intelligence

ANN: Artificial neural network

PE: Polyethylene

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CONTENTS

1 INTRODUCTION	1
2 THE TRADITIONAL TREATMENT METHODS	2
2.1 Mechanical Recycling	2
2.2 Chemical Recycling	4
2.3 Incineration Treatment	4
3 ARTIFICIAL INTELLIGENCE FEATURES AND APPLICATIONS	6
3.1 The application in date integrating	6
3.2 The application in details treatment	7
4 ANALYSIS THE SITUATION OF HANGZHOU	9
4.1 Analysis the advantages of Hangzhou, China	9
5 THE COMBINATION OF THE ADVANTAGES OF AI TECHNOLOGY AND THE TRADITIONAL TREAT METHODS	10
5.1 The combine with physical treatment method	10
5.2 The combine with the chemical method	11
5.3 The combine with the incineration	12
5.4 The advantages of applying AI technology in waste treatment industry	14
6 ETHICAL ISSUES IN THE AI APPLICATION	15
7 CONCLUSION	17
8 REFERENCES	19

FIGURES

FIGURE1: The simple treatment process in Bangladesh.....3
FIGURE2: The flow chart of the incineration.....5
FIGURE3: The simple structure of the machine learning system.....7
FIGURE4: Simple artificial neural network structure.....12

1 INTRODUCTION

As is known to all, the disposal of household waste has always been a very important status. The domestic waste includes: solid waste, sewage and harmful waste. For instance, solid waste includes: food residues, plastics, paper and textile (Chen 2020,4). Sewage comes from kitchens and washrooms. The batteries which are used belong to harmful waste.

Despite people already had some traditional treatment methods and renovation for plastic treatment. For example, mechanical recycling treatment, biological treatment, chemical treatment are commonly exist (Adhikari 2016,20-22). However, the treatment of household waste is still a problem. The plastics possess a large proportion in domestic waste because its low cost and availability, especially in package area. The plastic packages can be found in almost everywhere when picked the products. These plastic packaging are exactly what needs to be abandoned. As the development of the delivery industry, this urgency of well-dealing plastic waste is becoming increasingly serious.

With the progress and development of the era, the emerging AI technology has many potentials and development spaces. Artificial intelligence already be utilized in integrating data, controlling systems and anthropomorphic work. The combination with three traditional plastic waste treat methods and the AI technology is a new type fusion. This thesis explores the combination by listing the traditional waste disposal methods and the application of AI. People expected to improve the plastic waste process to be more efficient and precise, more friendly to the environment, and meet the demand for high-quality waste disposal in large city like Hangzhou.

2 THE TRADITIONAL TREATMENT METHODS

The plastic waste comes from several ways: construction, electronic demand and solid domestic waste. For the solid domestic waste-packaging, it is also a products until it was threw and recycled.

Nowadays, the awareness of recycling is increasing. And in view of people already have some plastic treatment methods, it is feasible to combine some new emerging technologies with the previous waste treatment methods. In order to readjust the treatment methods, it is particularly important to identify the principle of every method. The most common packaging material is PET and its derivative (Plastic Europe 2018). It is widely used in habitual lives. For this material, the waste treatment industries have diverse methods in recent years. There are three main ways to deal the plastic waste, mechanical method, chemical method and incineration method. But for the domestic waste, the types of the waste are municipal. In order to achieve the new-efficient waste management system, it is necessary to combine the traditional methods with new technology.

2.1 Mechanical Recycling

Mechanical recycling is the most familiar treatment method. And the most extensive used methods. It can be designed artificially. Most mechanical recycling systems include: collecting, sorting, cleaning, drying, shredding, and then return the plastic pellets to manufacture. Even some steps in the plastic recycle system can not full done by human. There are some factors will impact the quality of the human work, for instance carefulness, lack of experiences and flexibility. Also, if the system has some problems, the betterment of human may not efficient because of the huge system.

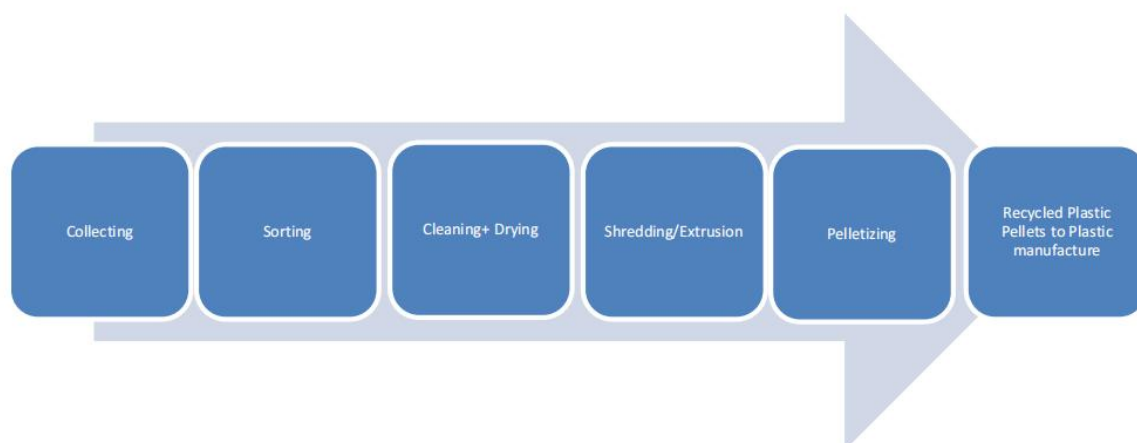


Figure1: The simple treatment process in Bangladesh. (Shimo 2014,31)

Most countries advocate garbage classification, which is convenient for the collecting of plastic waste. The collecting step is the pre-step of the garbage recycle system. Sorting step is the first step of the plastic waste treatment in the garbage recycle industry. Most of the sorting process is completed with automatic machines. Quite plenty of systems sort on sizes with sieves. It will cause inaccurate classification. Cleaning step already have some precise machines to utilize. For the plastic which has some oil, using the hot washer system is practical. It will effectively remove the impurities. Drying process can use screw press or thermal treatment to remove the water. The shredding machines are targeted. Most have the ideal solution. But will be imprecise if people choose one shredder in the recycle system. The pelletizing step is the last step before the plastic manufacture. The scale of the pelletizer depends on the target production. The pelletizer also has precise ideal solution, and they named with their materials processed (plastic recycling machine). These treatment steps can achieve the plastic waste be sorted, dried, shredded and pelleted. There steps are set simply before the re-manufacture. The processes of classification and manufacture provide great convenience for the recycling industry. The purpose sets at the beginning, the processes work follow the procedures.

2.2 Chemical Recycling

The principle of chemical recycling is breaking down into small molecules. The difference between chemical recycling and mechanical recycling method is that the mechanical one not alter the essence. The chemical recycling uses chemical reactions to remix the molecules. Alter the waste into feedstock, recycling and reproducing. It is more complex than the other treatment methods, also it needs more precise technology and high costs. Polyethylene (PE) is the common material in the domestic plastic waste. The PE material can be used in the bottles, delivery packages, and plastic bags. PE material made by ethylene. The chemical recycling method for PE is pyrolysis. The principle of the method is breaking the C-C bounds in the ethylene by pyrolysis. Also, there are two processes in the pyrolysis method, thermal or catalytic pyrolysis. The difference between two methods is the thermal pyrolysis only works by rising temperature to break the waste into molecules, but the catalytic pyrolysis will add catalysts to optimize from economic aspect and energy waste aspect. In that case, the catalytic pyrolysis can achieve lower temperature and shorter reaction time.

The chemical recycling methods have the advantages that the principle comply with the sustainability. At the same time, the high energy consumes, environmental influence and costly catalysts should be taken into consideration. Sometimes the use of the equipment meets the limited industrial applications.

2.3 Incineration Treatment

The appearance of incineration treatment decreases the need of landfill plastic treatment in special aspects. But the incineration method also has the responsibility for the carbon dioxide emissions. The plastic waste in the incineration treatment can be denied as domestic solid waste. Even though the system improved, still exist toxic influences. The toxic compounds are hard to remove from the exhaust gas by simple washing and adsorption processes (Chen 2020,12). There are three major incineration treatment methods: fluidized bed , moving grate and rotary kiln. The fluidized bed has the

highest efficiency by comparison. The efficiency achieved gets 90% (Akoore 2016,12-18). But no matter what exactly methods the system will apply, the regulatory system always needs to be set in the end. The regulatory systems filter and absorb the harmful substance to minimize the toxic effects on people and environment.



Figure 2: The flow chart of the incineration (Nagy & Kuti 2016,231-237)

1. Rotary Kiln 2. Post-combustion chamber 3. Heat recovery boiler 4. Absorber 5. active carbon reactor 6. Dust bag isolator 7. decontaminator 8. Washing Tower

Step 1 to 3 are the incineration processes. And step 4 to 8 are the regulatory system which will make sure the products obey the emission standard. The energy incineration needed is a consumable problem, but partial energy can be reuse. The other accompanying problem is the ash produced needs proper handling. A research has found that the transportation and collecting of plastic waste for incineration will cost 60 euro per ton. It is much more than the cost of normal waste recycling. Obviously, the low density of the plastic causes the cost of the collecting rising. In contrast, the phenomenon that incinerate the household waste without thinking influences because of the recycling costs are exist. So for achieving the effective deal the plastic waste, the achievement of convenient collect methods are needed.

3 ARTIFICIAL INTELLIGENCE FEATURES AND APPLICATIONS

Artificial intelligence (AI) is a product of technological development. It enables computers to simulate the learning abilities of human. Due to its efficiency and precision, it has been applied in multiple fields. Nowadays, only a small percentage of people are not familiar with AI, and reflects the wide application of this technology. The percentage of people who not support further develops AI is low, even only 4% (Saeidi 2020,50-51). These phenomena reflect the wide future of artificial intelligence.

3.1 The application in data integrating

Artificial intelligence can be widely used in the data areas. Its feature is effective. It is hard for human to process large amounts of data and summarize. Artificial intelligence can be understood as machine learning. Machine learning can make the electric systems with the abilities of autonomous learning and improve from the experiences (Breugelmans 2021,3). Its convenience makes artificial intelligence widely used in industry. Machine learning bases on the high cardinality and high dimensionality (Glan 2018,16). The industry which applies artificial intelligence can process large-scale information and source outcomes in processes.

Machine learning can run in T, P and E. T is the tasks, P is the performance measure and the E is experience. The learning process can be defined as performance in tasks, measured by step P and finally improve in experience (Li et al 2020,395).

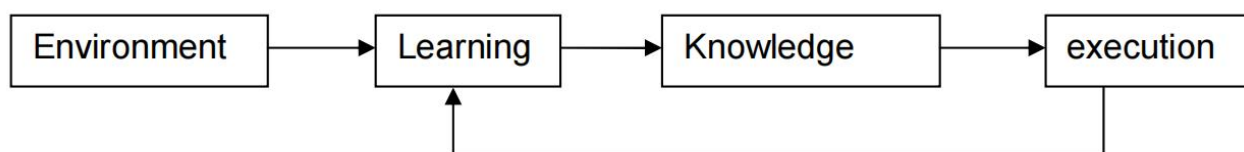


Figure 3: The simple structure of the machine learning system (Yang 2013,8)

The machine learning improves by running this system. Also, the machine learning generates its own knowledge and improves rules. This is a cycle system which the method machine can achieve comprehensive progress. Machine learning is not a simple cycle, there are many different algorithms includes. Machine learning is the foundation of the artificial intelligence technology, but AI is more complex and integrates more with information. The application of machine learning mostly achieves the integration of the human and computers (Yang 2013,10). So from particular perspectives, artificial intelligence can predict the outcome by analyzing data, especially in security issues have contributions. It brings significant benefits to the industries and deal the security problems.

3.2 The application in details treatment

Artificial intelligence technology also plays an important role in treating details. Its acuity and efficient make it increasingly applicable in various fields. Comparing with the automation, the biggest difference is that artificial intelligence has the lowest human intervention (Moilanan 2020,8). It is more experienced and reliable. Nowadays, already have some trending sustainable and controlling waste topic (Geilings 2021,20). In this area, the artificial intelligence can help in tracking details in processes and analyzing the diversity of products. The AI technology can behave better than the human. Its precise and quickness of analyzing are the reasons that prompt people to constantly evolve and develop it. The role of artificial intelligence technology in the waste-recycle area reflects in the fine

detail control. In recycling system, recent research shows that the algorithms in the artificial intelligence can construct convolutional neural network which has highest accuracy in sorting projects. It is observed that the algorithms have the accuracy level above 93% (Erkinay Ozdemir, M., Ali, Z., Subeshan, B. & Asmatulu, E 2021, 855-871). In order to achieve the consistency of the plastic recycling system, the precise neural network is recommended to be used in the classification and separation.

4 ANALYSIS THE SITUATION OF HANGZHOU

According this topic, the choice of the ideal cities in China has some limitations. The location should have superior geographical condition, high related demand, strong economy and sufficient talents. Hangzhou is totally suitable for importing emerging technology.

4.1 Analysis the advantages of Hangzhou, China

Hangzhou is a super-scale city with huge population. It is the center of the economy in Zhejiang province. Zhejiang province located in the coastal areas with convenient trade exchanges. Also, it is a city with potential and prospects. It is a priority city for national policy implementation. There are several national level technology development zones. Increasingly talents in technology fields are choosing to work in such city with challenges and opportunities. The government also plays an important role in the city construction. There are data indicating that the more and denser the recycling facilities have, the higher willingness to recycle and classified waste the resident have (Xu, L., Ling, M., Lu, Y. & Shen, M 2017,21-33). Fortunately, the government of Hangzhou is forward in the field of environment and waste-recycling. It will be an advantage to continue expand recycle field. These mean Hangzhou is a powerful place in the economy and policy area. In conclusion, Hangzhou, China is a suitable innovation city because its powerful economy, policy supporting, great demands for new technologies.

5 THE COMBINATION OF THE ADVANTAGES OF AI TECHNOLOGY AND THE TRADITIONAL TREAT METHODS

Above all the analysis, obviously the traditional plastic treatment methods have some problems in the efficiency or cost. Still have paces to innovate. Artificial intelligence as a new technology, has bright future, wide application, and potential for development. The fusion of traditional methods and new technology can make a great process in the plastic treatment. There are different kinds of methods in artificial intelligence that can utilize in the domestic traditional methods because of the different problems facing. The diverse methods correspond to the features of the artificial intelligence. And the artificial intelligence technology will further fuse with people's lives in the future.

5.1 The combine with physical treatment method

The mechanical plastic treatment is physical method. Even through it will not destroy the essence, it is consisted by several steps. In order to reform it as a new technology, every step aims at controlling precise. Artificial intelligence has the control accuracy that can improve this situation. For the PE plastic bottles, the industry had used the washing lines for the washing step. The PE plastic bottles washing line is available for variety of plastic waste. Even though the treatment steps can adjust depends on the raw material, but need manual handling and the consumption of labor (plastic cycling machine).

If applying artificial intelligence technology into the treatment processes, can reduce the cost and control details more precise. The decision tree is a kind of classified technology in AI which can applied in the physical processes. The principle of the decision tree is extracting patterns from irregularities. And the outcome of the prediction is similar with the prediction of experts .The decision tree already used in the classification and compression of the waste (Kuritcyn, P et al 2015,3-4). The

decision tree helps to achieve the purpose of efficient and low-cost process systems in the industry. The decision tree include nodes, branches and splitting, stopping and pruning. The nodes are the original data and situation which all the outcomes base. The branches and splitting are the analyzing of possibilities. Also, is the main part of the decision tree. The diversity of the decision tree establishes on the splitting. Eventually, the stopping and pruning aim at preventing the over-complex. This step makes the outcomes of the analyzing reasonable.

The decision tree technology is the most useful tool for classification, prediction and data manipulation. This technology has the advantages of simplifying the complex relationship between the original data and diverse outcomes. And all the possibilities come from scientific assumption (Song & Lu 2015,130-135). Above all, the application of the decision tree in the physical plastic waste treatment system brings highly efficiency improvement. The fusion can achieve the precise classification and separation. The shredding standards can be changed based on the raw material or the targeted products. There is no need to adjust artificially, and avoid the occurrence of the errors in some extents.

5.2 The combine with the chemical method

The chemical treatment method has some limitations. Recently the progressive research finds that the pyrolysis of the plastic can form synthetic oil (Thiounn & Smith 2020,1347-1360). But the municipal solid waste own different melting and reaction temperatures. It has difficulties to separate the mixed plastic waste. The artificial neural network(ANN) is widely used in the pyrolysis of the reactants with complex compounds. The ANN can predict the behaviour of the output by detection (Ge, S.et al 2021,114638). The artificial neural network composes of single neuron. The relationship and algorithms make the neurons alive (Suzuki 2011,4). The multiple layers ANN system can be settled.

Decisions and analysis generate based on multiple layers. And the layers achieve the simplify of complex compounds and relationship.

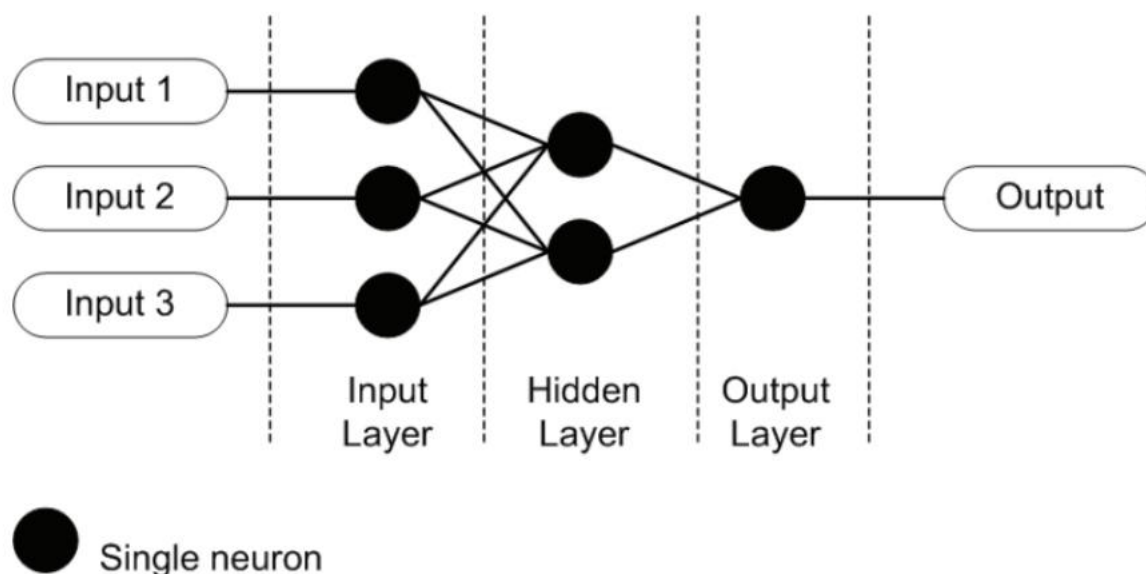


Figure 4: Simple artificial neural network structure(Suzuki 2011,4)

For the catalytic pyrolysis, the parameters can be set as reactant's temperature, air, catalyst and the outputs. The prediction demonstrate the accuracy of the ANN and also reflect the parameter of the input. Combine ANN with catalytic pyrolysis provide the effective condition for the reactants to produce synthetic oil. The artificial neural network technology help the pyrolysis reaction more clear and convenient. Catalytic pyrolysis not only decreases the consumption of the heat energy and costly catalyst, also produces useful oil which can be used, and playing an important role in the deep development of chemical plastic waste treatment.

5.3 The combine with the incineration

People utilize the simple incineration in the past few years. The ash and gas product from the incineration are toxic and harmful for both and the health and the environment. Nowadays,the

industries apply new reactors. The basic principle is still melting the plastic by high temperature, and the progress shows in the products. Part of the products can be condensed into pyrolysis oil by adding recycled liquid. This pyrolysis treatment method works automatically and efficiently, and it is able to handle by-products well (Yu 2023,7). The whole process requires high accuracy for temperature and stirring. The precise feature of artificial intelligence can combine with the features of incineration. Only input the data and response procedures are needed. Bring more effective control of pollutants brought by incineration.

The essence of applying artificial intelligence in incineration domestic waste treatment is modeling. The deep learning is useful in this procedure. The deep learning technology can be applied in some areas. The deep learning is a branch of the machine learning. And it has the similarity with the ANN. The different point between them is the ANN focuses more on the relationship between elements. ANN can perform better in the prediction and solve complex situations. The deep learning can offer better models and increasingly improve the accuracy of unsupervised works (A.N.F., Sulaima, M.F., Razak, I.A.W.A., Kadir, A.F.A. & Mokhlis, H 2023,16907). For the incineration, it can search the co-melting temperature of solid waste. The incineration requires a better model to identify the substances and their melting temperatures. Deep learning involves building models and provides relationships with keywords and outcomes. The deep learning achieves information retrieval efficiently. Applying deep learning technology in the incineration process can analyze the needed temperature and suitable equipment design automatically by creating relationships with the substances and solutions. Also, it is advisable to design a closed container that the gas generated will not pollute the environment. The closed container with deep learning will efficiently treat the solid plastic waste. It is necessary to take the environmental influence into consideration. From the perspective of incineration, co-melting saves energy. For the pollution, improved incineration avoids the gas releasing.

5.4 The advantages of applying AI technology in waste treatment industry

Above all, the fusion of AI and plastic waste treatment methods has obvious advantages. The new technology brings more possibilities for the industry which show in the low-cost and high-accuracy. The application of AI is the important key for enterprises to achieve digital intelligence, and helping the industries adapt the development needs of the new area. Also, the fusion of variety high technologies can more satisfy recycle require for plastic treatment industry. The layout of the industry can be improved in some aspects when the industry fuses with artificial intelligence. The layout can change based on the rising the efficiency of the processes.

In general, the fusion of the artificial intelligence and the domestic plastic waste treatment industry is a great progress. The achievement of the efficient and accuracy are exist. And the cost problems and profit problems are the industries permanent facing, can be released by fusing new technology. The fusion of the new technology and traditional treatment methods is a great tend. It signs the revolution of traditional technology and promotes industrial transformation and upgrading. And promote the extent of the industrialization.

6 ETHICAL ISSUES IN THE AI APPLICATION

The ethical issue is the greatest problem in the application of the artificial intelligence. There are different regulations based on different areas. For instance, the Chinese government publish new document in 2022 which mainly apply in promoting the AI technology application in the southern of the China. And even list AI services in the “low-risk” system after testing. Then put the artificial intelligence technology into mass-production (Dunshin 2022,12). In the daily lives, in some hotels in China, the encounter robots delivering is ubiquity. This phenomenon also reflects the wide application of AI in China. In other words, developing emerging technology in such environment is also more advantages.

But the ethical issues are real exist. People worried about some aspects. Some like, job placement, privacy, security, loss of society connection and so on. The intervene of the artificial algorithm makes some processes working without human taking in part. And human should input the data before the algorithm works. The data including private information, there is a potential risk of information leakage. This phenomenon lets human and society worried about the future whether will keep going. And the risks increasing by uncertainties. The AI technology develop unknown knowledge are unpredictable. People hope that the artificial machines can obey the ethical principles, but only theoretically easy. For instant, people design the robots to work staying away from danger. Fundamentally, the robots need to know what is danger (Wang & Siau 2018,4). There are problems that people can not ignore and will expose or disappear with the development of technology. These issues are waiting for solve in the future. Nevertheless, the artificial intelligence will ultimately becoming an instrument which helps people construct the efficient and bright future. Human will peace coexistence with AI in the end. In the new century, human should continuously adapt and innovate, exploring the integration of technology and activities in human lives. And constantly improving ourselves to meet the future challenges. It is the progress and integration of technology that

enables society to diversify around the world. How to use and what outcomes the artificial intelligence brings depend on the activities of human.

7 CONCLUSION

With the development of the technology and economy, more and more rising cities input and try new technological products according to the needs. The emerging technological products solve the problems in producing and living. The artificial intelligence is the most distinctive representative. Its precise and efficient features make it the most widely used new technology. Hangzhou, China as a large, intensive population, development need for new technologies city. Hangzhou is attracting talents and has a emerging powerful future in high-new technologies. Also in some aspects, Hangzhou city has the necessity for treat the domestic plastic waste well. Hangzhou is available for trying emerging technological methods.

Nowadays the plastic waste still occupy a large proportion in the multiple solid waste. Specially in the packaging area, because the development of the times, people are pursuing convenience. People also do not have time to sort the plastic carefully and move the plastic waste to the professional treatment center. So dealing the plastic waste is important for example PE. The combination with traditional plastic and AI technology is a new type fusion. It has extensively prospect in the future. The emerging technology can be applied in the treatment processes that make them more accurate and more cost-saving. But this system still has limitations, the data treatment and the response to unexpected situations are indeterminacy. Even though the artificial intelligence makes the lives of human more convenient and efficient, the application of AI technology faces complex challenges and issues. In general, there are still places for integration between technology and ethical issues. People will continue to improve the application of AI technology in the future in order to bring great progress for every area in the lives.

In another version, people also need to reduce the consumption of the plastic. Even though the century keeps improving, the technologies will renew. Only improve the treatment methods is not permanent.

The concepts of people also require to constantly improve. People need to have environmental awareness and continuously contribute to improving and maintaining the environment. Only by working in two directions can achieve our world more and more beautiful.

REFERENCES

- Adhikari, P., 2021. *Sorting and recycling solid plastic waste: Challenges and opportunities*.20-22
- Akoore, A.A., 2016. *Municipal Solid Waste Incineration For Accra Brewery Limited (Ghana)*.12-18
- Ali, A.N.F., Sulaima, M.F., Razak, I.A.W.A., Kadir, A.F.A. and Mokhlis, H., 2023. *Artificial intelligence application in demand response: Advantages, issues, status, and challenges*.16907-16922.
- Breugelmans, A., 2021. *Implementing machine learning (AI) in game development with Unity*.3
- Chen, Y., 2020. *System of waste separation: Status and challenges in China*.4
- Dunshin, I., 2022. *Moral and ethical side of using of AI in modern life*.12
- Erkinay Ozdemir, M., Ali, Z., Subeshan, B. and Asmatulu, E., 2021. *Applying machine learning approach in recycling. Journal of Material Cycles and Waste Management*.855-871.
- Ge, S., Shi, Y., Xia, C., Huang, Z., Manzo, M., Cai, L., Ma, H., Zhang, S., Jiang, J., Sonne, C. and Lam, S.S., 2021. Progress in pyrolysis conversion of waste into value-added liquid pyro-oil, with focus on heating source and machine learning analysis. *Energy Conversion and Management*.114638.
- Geilings, B., 2021. *Using Artificial Intelligence to positively impact the beer brewing process*.20
- Glan, J., 2018. *Potential Artificial Intelligence Features for Digital Marketing Performance Analytics Product*.16
- Gradus, R.H., Nillesen, P.H., Dijkgraaf, E. and Van Koppen, R.J., 2017. *A cost-effectiveness analysis for incineration or recycling of Dutch household plastic waste. Ecological Economics*.22-28.
- Kuriteyn, P., Anding, K., Linß, E. and Latyev, S.M., 2015, February. *Increasing the safety in recycling of construction and demolition waste by using supervised machine learning. In Journal of Physics: Conference Series* .3-4
- Moilanen, K., 2020. *Artificial Intelligence: An analysis of perceptions of the impact of AI on the financial labour market*.8

Ágnes, N. and Rajmund, K.U.T.I., 2016. *The environmental impact of plastic waste incineration. AARMS–Academic and Applied Research in Military and Public Management Science*.231-237.

Erkinay Ozdemir, M., Ali, Z., Subeshan, B. and Asmatulu, E., 2021. *Applying machine learning approach in recycling. Journal of Material Cycles and Waste Management*, 23, pp.855-871.

Plastic Europe 2018

Available at: <https://plasticseurope.org/changingplasticsforgood/>

Accessed: 26 January,2024

Plastic recycling machine

Available at:<https://www.plasticrecyclingmachine.net/>

Accessed: 24 January,2024

Saeidi, S., 2020. *People’s perception and expectation of AI capabilities (Analyzed with KNIME analytics platform)*.50-51

Wang, W. and Siau, K., 2018. *Ethical and moral issues with AI*.4

Shimo, M.H.U., 2015. *Plastic Recycling in Bangladesh, What needs to be done?*.31

Shrestha, A. and Mahmood, A., 2019. *Review of deep learning algorithms and architectures*. 53040-53065.

Suzuki, K. ed., 2011. *Artificial neural networks: methodological advances and biomedical applications*.4

Thiounn, T. and Smith, R.C., 2020. *Advances and approaches for chemical recycling of plastic waste. Journal of Polymer Science*.1347-1364.

Xu, L., Ling, M., Lu, Y. and Shen, M., 2017. *External influences on forming residents’ waste separation behaviour: Evidence from households in Hangzhou, China. Habitat International*6.21-33.

Yang, Y., 2013. *A study of pattern recognition of Iris flower based on Machine Learning*.8-10