A Study on the Introduction of Artificial Intelligence Technology in the Water Treatment Process

By

JEONG, Seong Il

CAPSTONE PROJECT

Submitted to

KDI School of Public Policy and Management

In Partial Fulfillment of the Requirements

For the Degree of

MASTER OF PUBLIC MANAGEMENT

2020

A Study on the Introduction of Artificial Intelligence Technology in the Water Treatment Process

By

JEONG, Seong Il

CAPSTONE PROJECT

Submitted to

KDI School of Public Policy and Management

In Partial Fulfillment of the Requirements

For the Degree of

MASTER OF PUBLIC MANAGEMENT

2020

Professor Lee, Junesoo

A Study on the Introduction of Artificial Intelligence Technology in the Water Treatment Process

By

JEONG, Seong Il

CAPSTONE PROJECT

Submitted to

KDI School of Public Policy and Management

In Partial Fulfillment of the Requirements

For the Degree of

MASTER OF PUBLIC MANAGEMENT

Committee in charge:

Professor Lee, Junesoo, Supervisor Junesoo Lee ________________________

Professor Kim, Seong Han ________________________

Approval as of May, 2020

EXECUTIVE SUMMARY

Today, we stand in front of a huge wave of change named the "Fourth industrial revolution." Key technologies of the Fourth Industrial Revolution include artificial intelligence, the Internet of Thing (IoT), cloud computing, big data analysis, etc. These technologies will lead to an intelligent information society, and platform services will change every aspect of society from economic and work.

This paper proposes several introductions of Artificial Intelligence Technology to improve water management. AI Technology secure a leadership position in the unfolding revolution and expedite the realization of an intelligent information company. K-water has to secure innovative technologies in advance as the foster related industries and upgrade services in order to generate new value and ensure the competitiveness of its intelligent water system.

The K-water should take significant steps to thoroughly prepare for the coming Fourth Industrial Revolution, such as Artificial Intelligence-based autonomous Water Purification Plant with developing a creative water treatment process. The artificial intelligence system will be able to secure technological competitiveness in the water industry and secure future growth engines in the water industry by securing intelligence information technology, which is key to the fourth industrial revolution.

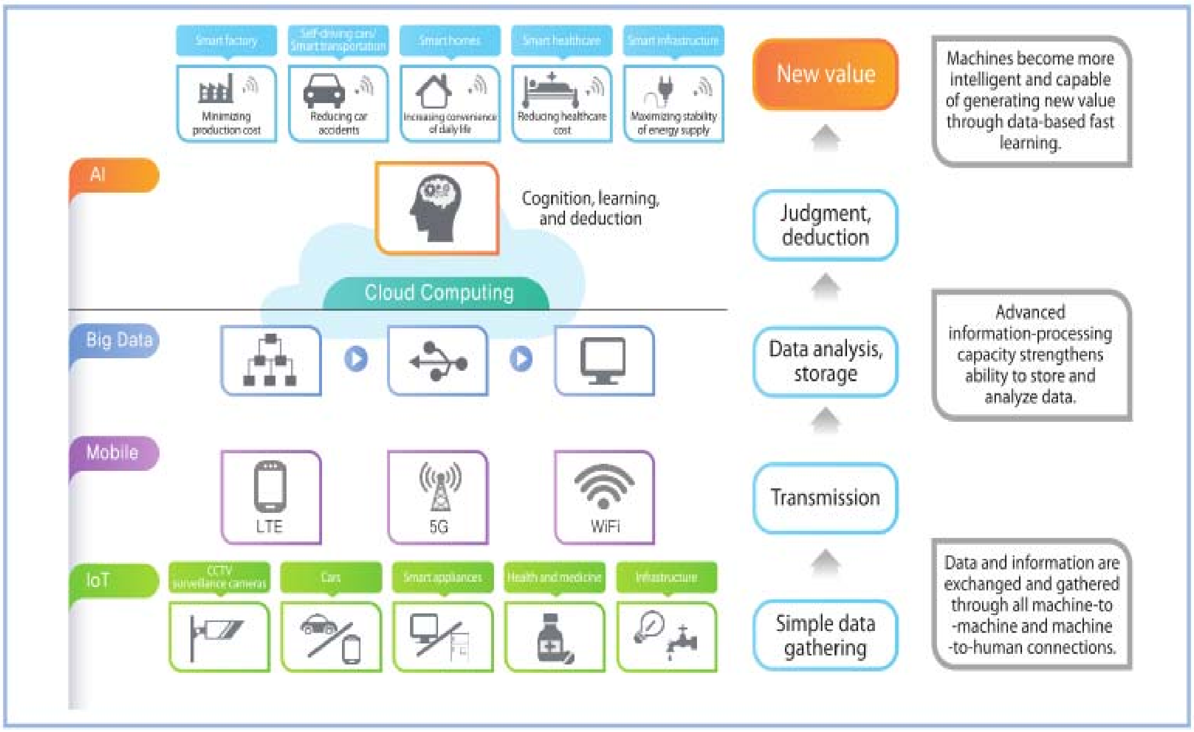
TABLE OF CONTENTS

I. Introduction

A. Background of the study

The fourth industrial revolution is leading to intelligent ICT by increasing productivity and performance based on artificial intelligence technology. ICT technology is changing the basic structure of the entire industry. Intelligent ICT will increase productivity and lead to fundamental reform of existing production factors such as labor and capital as well as industrial structure. Information and communication technology (ICT), combined with platform services, breaks down barriers between industries and converges to enable new added value and new services.   Figure 1 shows the concept of Intelligent ICT.

Figure 1. Concept of Intelligent ICT



(Source: MSIP, Ministry of Science and ICT)

Advances in artificial intelligence technology will change the overall structure of the industry, change the type of work and, accordingly, severely change people's lifestyles.

As machines incorporating artificial intelligence technology replace human workers in all sectors of society, productivity will increase, labor time will decrease, and social changes and economic benefits will increase. On the other hand, this automation will replace simple, repeated human labor and increasing demand for highly professional and skilled personnel.

Table1 compares machine automation and intelligent ICT. But intelligent ICT technology will not be able to cope with creative and emotional areas such as art.

Table 1. Comparison of Electricity and Intelligent ITC.

	Machine automation	Intelligent IT
Role	Replaces human's physical labor	Replaces human's mental labor
Scope of application	All industrial and life activities that require electricity	All areas of industrial and life activities that require decision making (except for creative and emotional activities))

(Source: MSIP, Ministry of Science and ICT)

However, intelligent ICT is expected to extremely change a country's economic and social structure. Therefore, K-water and related industries need to prepare for these changes. K-water needs to secure innovative technologies in advance, foster related industries, and upgrade its services to create new information and secure the competitiveness of the information society.

B. Statement of the problem

In the domestic water supply facilities, all the water treatment processes (water intake → water purification → supply) are operated by real-time remote monitoring control in the central control room and the operator operates the system with the facility operation management manual (facility, water quality, etc.) of each site by remote or manual method.

The current operation method is mainly focused on post-recovery after the accident due to the lack of preliminary forecasting technology (odor smell, accident location, supply change, etc.) in the event of water quality and pipeline accidents. Operation deviation occurs depending on the capacity of the operator due to the experience and know-how of the workers, and accidents related to water quality and pipeline occurred frequently. The monitoring and control system status in the waterworks can be divided into four levels of automation according to the level of control by process. Table 2 shows the level of automation at K-water's waterworks.

Table 2. The level of automation at K-water's waterworks

Division	Intake	Chemical Injection	Mix	Coagulant	Filter	chlorine	Ozone
Current level	Manual	Semi Automation	Semi Automation	Semi Automation	Semi Automation	Semi Automation	Semi Automation

The current monitoring and control system centered on unit processes is showing limitations in proactive response to various environments and the operation of linkage between systems. In K-water's case, water operation data is generated in minute, hour and day data and is connected internally and externally through the real-time water information system, which sends real-time data to the headquarters in real-time, but the current system centered on the transmission of real-time data is operated with simple real-time expression without any analysis or prediction functions. Figure 2 shows the SWOT analysis of K-water.

Figure 2. SWOT Analysis

Strengths	Weaknesses
■ Top level ICT infrastructure ■ World-class manufacturing infrastructure ■ A lot of know-how in water management ■ Aggressive investment in R&D ■ Having water-related big data	■ Lack of challenges to take risks ■ Hesitant to invest in innovative technology ■ Lack of quality data ■ Lack of applications of AI technology
Opportunities	**Threats**
■ Applying Intelligent ICT to solve water problems ■ Applying Intelligent ICT to strengthen competitiveness of major industries ■ Applying knowledge and data to achieve greater growth in the global market ■ Pioneering new markets of water industry	■ Global Corporations Entry to into Korean industries ■ Rapidly changing structure of industries ■ Increased risk of hacking and vulnerability to privacy ■ Preempting technology by overseas water companies

C. Purpose of the study

This report examines the artificial intelligence technology applicable to each water treatment process in detail and develops and applies artificial intelligence (AI) based software to build a scientific system for producing high-quality tap water based on advanced operating technologies. Also, it is possible to create a stable workplace environment by forecasting demand, and by contributing to a big data-based autonomous operation system, it can contribute to productivity improvement and cost reduction by reducing operating manpower, electricity bills, and chemical costs.

Also, it is possible to secure technological competitiveness in the water supply field by applying a customized artificial intelligence system to domestic waterworks. Also, securing intelligent information technology, which is the core of the Fourth Industrial Revolution, is expected to enhance competitiveness in the water industry and future growth engines in the water supply sector.

II. Review of Literature and Cases

A. Literature Review

MajidBagheri (2019) focused on water and wastewater treatment systems and reviewed artificial intelligence (AI) and machine learning (ML) techniques to better control membrane contamination in the filtration process. Artificial neural networks (ANNs), fuzzy logic, gene programming and model trees are successfully used as modeling techniques. The results show that well-known ANNs, such as multilayer perceptron and radial basis functions, can predict membrane fouling with errors close to zero, and R2 as 0.99.

Xiaodong Li (2019) reviewed urban water demand forecasts using a variety of artificial intelligence-based approaches such as fuzzy logic systems, support vector machines, extreme learning machines, ANN and ARIMA, and a hybrid model consisting of the integration of two or more artificial intelligences Approach has been applied. This paper describes how various artificial intelligence approaches play an important role in the prediction of water demand in the city and recommend future research directions.

B. Review of AI algorithms

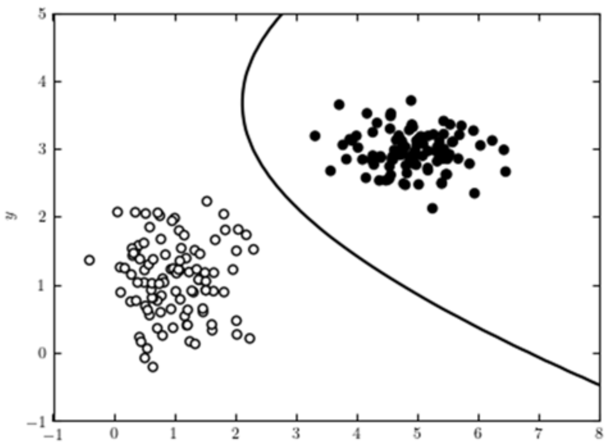
The most well-known algorithm among artificial intelligence algorithms is described by quoting the "Medium.com" internet site data. Mechanical learning and statistical classification is how a computer program learns from a given data input and then classifies new observations based on this learning.

This data set can simply be a by-class. Examples of classification problems include speech recognition, handwriting recognition, biometric recognition, and document classification. There are the following types of classification algorithms in machine learning.

1. Naive Bayes Classifier

A classification scheme based on Bayes' theorem assumes independence between predictors. In short, the Naive Bayes classifier assumes that the presence of one feature of a class is not related to the presence of another. Even if these features depend on each other or on the presence of other features, all these features independently contribute to the probability. The Naive Bayes model is easy to deploy and is especially useful for very large data sets. In combination with simplicity, Naive Bayes is known to be superior to very sophisticated classification methods.

Figure 3. Naive Bayes Classifier

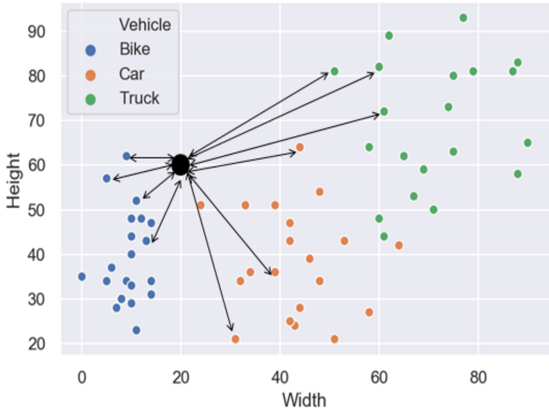


Source: Medium.com

2. Nearest Neighbor

k- The nearest neighbor algorithm is a classification algorithm and is supervised. Use to learn how to label different points using multiple labeled points. To label a new point, look at the point labeled closest to the new point (closest neighbor) and let that neighbor vote. So the label with the most neighbors is the label for the new point ('k' is the number of neighbors you are checking).

Figure 4. Nearest Neighbor

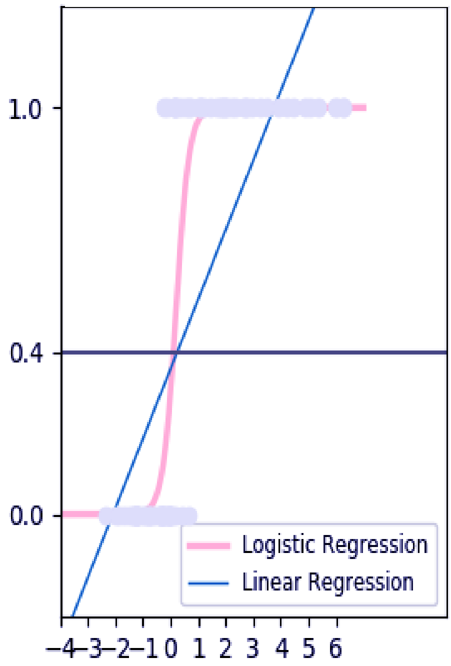


Source: Medium.com

3. Logistic Regression

Statistical method for analyzing a dataset with one or more independent variables to determine the result. The result is measured in dichotomous variables (there are only two possible results). The goal of logistic regression is to find the most suitable model that describes the relationship between the dichotomous characteristic of interest (dependent variable = response or outcome variable) and a series of independent (predictor or descriptive) variables. This is better than other binary classifications, such as the nearest neighbor, because it quantitatively explains the factors that lead to the classification.

Figure 5. Logistic

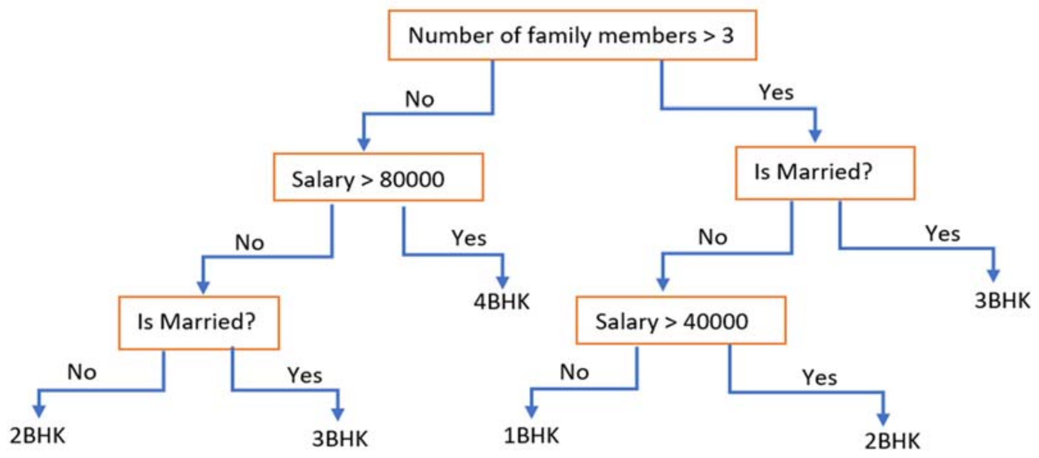


Source: Medium.com

4. Decision Trees

Decision trees build classification or regression models in the form of tree structures. At the same time, as the dataset is broken down into smaller subsets, the relevant decision trees are gradually developed. The end result is a tree with decision nodes and leaf nodes. Decision nodes have more than one branch, and leaf nodes represent classifications or decisions. The highest decision node in the tree that corresponds to the best predictor, called the root node. Decision trees can handle both categorical and numeric data.

Figure 6. Decision Trees

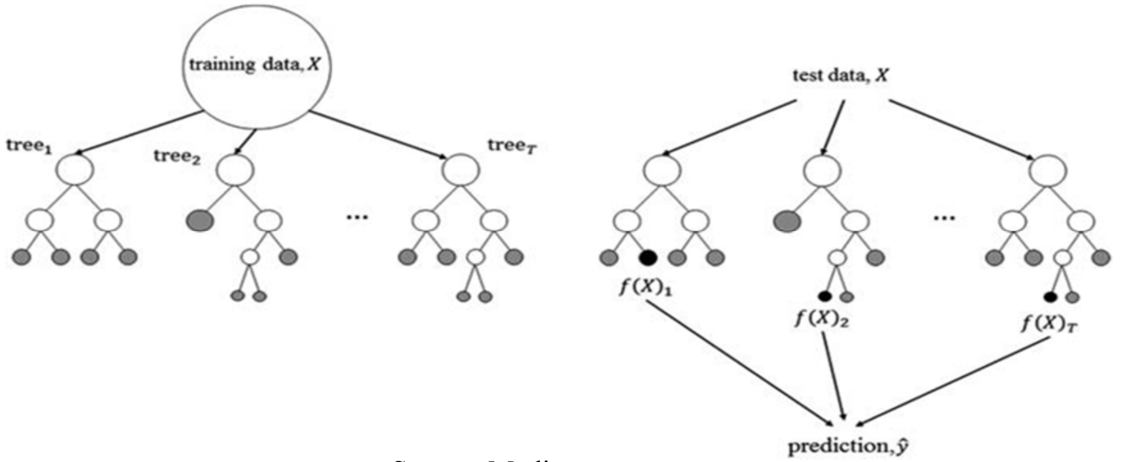


Source: Medium.com

5. Random Forest

Random Forest or Random Decision Forest is an ensemble learning method for classification, regression, and other tasks that works by constructing multiple decision trees at training time and outputting classes that are class mode (classification) or average prediction (regression). Random decision forests of individual trees correct the habit of decision trees over-adapting to the training set.

Figure 7. Random Forest

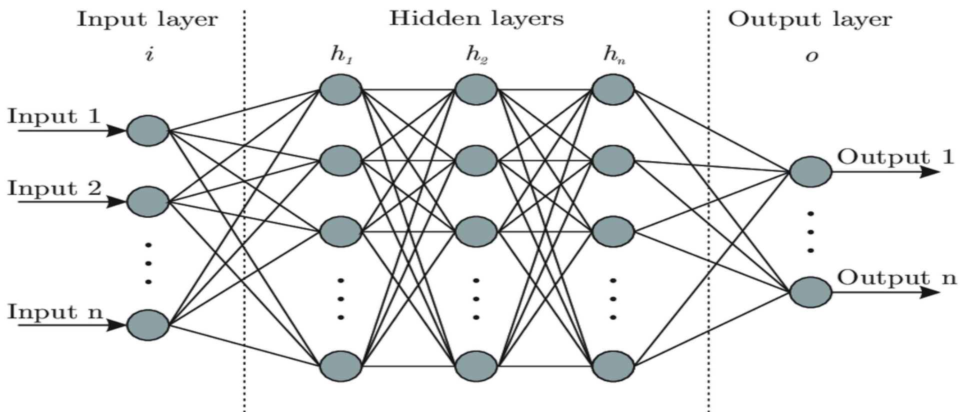


Source: Medium.com

6. Neural Network

Neural networks consist of units (neurons) arranged in units that transform an input vector into some output. Each unit takes an input, applies a (nonlinear) function, and then passes the output to the next layer. In general, a network is defined as a feed forward.

Figure 8. Neural Network



Source: Medium.com

The device feeds output to all devices on the next layer, but there is no feedback on the previous layer. Weights are applied to signals passing from one unit to another, which are adjusted in the training phase to tailor the neural network to specific problems.

III. Analysis of AI Technology Application in Water Treatment

A. Analysis of Artificial Intelligence Technology in Water Treatment Process

Artificial Intelligence system is intended to determine the various situations that occur during the water treatment process and improve the efficiency of water production to ensure the stability of water quality. Structural, semi-structural and non-structural types are in building an optimal decision-making system using artificial intelligence-based analysis technology. Decision-making system (DSS) can be broadly divided into process control and analysis and prediction systems.

The component technologies applicable to waterworks are shown in Table 3 below.

Table 3. Applicable model of artificial intelligence

Process control	Analysis and Forecasting system
❶ Optimum control of pump ❷ Optimal Control of Inlet Valve ❸ Optimal Coagulant Control ❹ Optimal control of chlorine ❺ Optimum control of sedimentary sludge ❻ Optimal control of filter ❼ Optimum drain water control ❽ Equivalent control of reservoir ❾ Pipe leak detection	Ⓐ Prediction of the Demand for Water Supply Ⓑ Prediction of Water Supply Time Ⓒ Measurement and analysis of pump efficiency Ⓓ Calculation and analysis of sludge generation Ⓔ Prediction of Water quality Ⓕ Process simulation program Ⓖ Self-diagnosis of Equipment and failure prediction

1. Intake Process

The intake process is the initial stage of the water treatment process, and the production and supply volume is controlled by the pump or valve control in the intake station.

It can be expected to reduce the production cost, power cost by establishing an autonomous operation system applying an artificial intelligence algorithm to automatically determine the quantity of intake based on prediction of demand.

The current operation method is to manually decide the increase and decrease of water intake to respond immediately when the demand increases rapidly. As a result, the power cost is increasing due to the pump operation to adjust the water intake during the high electricity rate. The waterworks business needs to apply the optimal pump and valve control program by predicting the water demand based on big data analysis by applying ❶ Optimum Control of Pump and ❷ Optimal Control of Inlet Valve technology to solve these problems,

	Input of control	Output of control	Process of big data analysis
❶ Optimum control of pump	Intake Flow, Pump status, Water level, Time of pump operation, Control priority	Number of pump operation, Pump control signal, Set value of flow,	Classification, Cluster,
❷ Optimal Control of Inlet Valve	Intake Flow, Valve status, Water level, Control priority	Gage of Valve operation, Valve control signal, Set value of flow,	Classification, Cluster,

2. Chemical Process

The current chemical injection process is operated by manual determination of chemical injection rate and control of inflow flow rate by Jar-test and lookup table. Factors affecting the coagulant injection rate include turbidity, pH, alkalinity, electrical conductivity, organic matter concentration, and water temperature. The limitation of the current operation method is that it is not immediately applicable to changes in water quality and changes in chemical types due to the manual determination of chemical rate by people.

Methods for solving these problems is the development of ❸Optimal Coagulant Control which is an automatic determination and prediction program of drug injection rate by artificial intelligence algorithms considering raw water quality and subsequent process water quality,

Autonomous operation system will greatly contribute to reducing chemical costs and improving tap water quality.

	Input of control	Output of control	Process of big data analysis
❸ Optimal Coagulant Control	Turbidity, pH, Alkalinity, Electrical conductivity, Temperature	Injection rate of chemical, Set value of chemical rate	Regression analysis

a. Regression Analysis between Raw Water Quality and Coagulant Injection Rate

This report will analyze the correlation between coagulant injection rate and raw water quality, and calculate regression polynomials through regression analysis based on significant factors to establish the drug injection rate operation system, also, it will compare the error with the actual coagulant injection rate. This report analyzed the data of the Unmun Purification Plant located in Unmun, Gyeongsangbuk-do, for data analysis. Raw water of turbidity, alkalinity, electrical conductivity, pH, temperature and coagulant injection rate time data are analyzed.

The data is analyzed from January 1, 2017, to May 5, 2018.

Table 4. Data of raw water quality, coagulant rate

Time	pH	Turbidity	Temperature	Electrical conductivity	Alkalinity	Coagulant injection rate
2017-01-01	7.20	2.07	7.80	71.03	15.62	13.59
2017-01-02	7.23	2.23	7.60	70.39	15.23	14.78
2017-01-03	7.23	2.20	7.50	71.25	15.27	14.58
2017-01-04	7.22	2.05	7.47	71.51	15.37	14.00
2017-01-05	7.22	1.85	7.46	71.38	15.27	13.82
2017-01-06	7.23	1.73	7.52	71.28	15.37	13.88
2017-01-07	7.24	1.72	7.46	71.42	15.29	14.27
2017-01-08	7.25	1.70	7.41	71.70	15.20	14.08
2017-01-09	7.24	1.75	7.41	71.90	15.36	13.63
2017-01-10	7.23	1.78	7.26	71.90	15.60	14.13
2017-01-11	7.24	1.67	7.07	71.46	15.58	14.33
2017-01-12	7.25	1.65	6.90	71.49	15.49	13.58
2017-01-13	7.27	1.62	6.76	71.79	15.21	13.60
2017-01-14	7.27	1.65	6.53	71.73	15.07	13.46
2017-01-15	7.28	1.60	6.29	71.62	15.12	13.54
2017-01-16	7.31	1.77	6.15	71.49	15.09	13.84
~ syncopation ~						
2018-05-08	6.76	1.92	10.69	89.35	21.67	12.11
2018-05-09	6.73	1.57	10.33	90.09	21.97	13.71
2018-05-10	6.93	1.80	10.79	88.82	20.90	12.89
2018-05-11	7.10	1.48	10.66	89.91	21.62	12.54
2018-05-12	7.10	1.27	10.66	89.68	21.13	11.25
2018-05-13	7.09	1.23	10.89	88.93	19.42	11.14
2018-05-14	7.08	1.20	10.85	89.26	19.93	11.22
2018-05-15	7.07	1.26	10.94	89.56	19.96	11.11
2018-05-16	7.05	1.14	10.89	90.04	19.80	10.93
2018-05-17	7.05	1.13	11.11	89.17	18.91	10.85
2018-05-18	7.05	1.35	10.96	89.14	20.94	10.74
2018-05-19	7.05	1.36	10.64	89.25	23.46	11.99
2018-05-20	7.04	1.41	10.79	88.55	21.76	11.76
2018-05-21	7.03	1.42	10.72	88.29	20.71	11.83
2018-05-22	7.02	1.43	10.83	88.55	21.05	11.53
2018-05-23	7.01	1.32	10.93	88.77	20.80	11.46
2018-05-24	7.01	1.43	11.24	88.05	21.96	12.05
2018-05-25	6.99	1.48	11.16	88.49	24.14	11.73

b. Correlation analysis

The correlation analysis of the coagulant injection rate with the raw water quality is shown in the table below.

Table 5. Data of raw water quality, coagulant rate

	pH	Turbidity	Temperature	Alkalinity	Electrical conductivity	Coagulant injection rate
pH	1					
Turbidity	0.240487646	1				
Temperature	-0.697852868	-0.17571	1			
Alkalinity	-0.063563649	0.252428	-0.21251	1		
Electrical conductivity	-0.100338313	0.342534	0.0173	0.676461	1	
Coagulant injection rate	0.295636023	0.890403	-0.14606	0.199537	0.350738	1

Correlation analysis showed the highest correlation between coagulant injection rate and turbidity, which was 0.89.

The stepwise regression method was used to calculate the regression polynomial through the regression analysis of coagulant injection rate and raw water quality. The results are shown in the following table.

c. Results of stepwise regression

Step 1 - Entering variable: Turbidity

Summary measures

Multiple R	0.8904
R-Square	0.7928
Adj R-Square	0.7924
StErr of Est	1.5028

ANOVA Table

Source	df	SS	MS	F	p-value
Explained	1	4355.6369	4355.6369	1928.6368	0.0000
Unexplained	504	1138.2345	2.2584		

Regression coefficients

	Coefficient	Std Err	t-value	p-value
Constant	9.6755	0.1205	80.3210	0.0000
Turbidity	1.7694	0.0403	43.9162	0.0000

Step 2 – Entering variable: pH

Summary measures

		Change	% Change
Multiple R	0.8944	0.0040	%0.4
R-Square	0.7999	0.0071	%0.9
Adj R-Square	0.7991	0.0067	%0.8
StErr of Est	1.4785	−0.0243	−%1.6

ANOVA Table

Source	df	SS	MS	F	p-value
Explained	2	4394.3734	2197.1867	1005.1724	0.0000
Unexplained	503	1099.4979	2.1859		

Regression coefficients

	Coefficient	Std Err	t-value	p-value
Constant	1.7982	1.8750	0.9590	0.3380
Turbidity	1.7281	0.0408	42.3164	0.0000
pH	1.1228	0.2667	4.2097	0.0000

Step 3 – Entering variable: Water temperature

Summary measures

		Change	% Change
Multiple R	0.8992	0.0049	%0.5
R-Square	0.8086	0.0088	%1.1
Adj R-Square	0.8075	0.0084	%1.1
StErr of Est	1.4471	−0.0314	−%2.1

ANOVA Table

Source	df	SS	MS	F	p-value
Explained	3	4442.6087	1480.8696	707.1463	0.0000

Unexplained	502	1051.2627	2.0941		

Regression coefficients

	Coefficient	Std Err	t-value	p-value
Constant	-7.4603	2.6626	-2.8018	0.0053
Turbidity	1.7302	0.0400	43.2849	0.0000
pH	2.3044	0.3588	6.4217	0.0000
Water temperature	0.1089	0.0227	4.7993	0.0000

<u>Step 4 – Entering variable: electrical conductivity</u>

Summary measures

		Change	% Change
Multiple R	0.9023	0.0031	%0.3
R-Square	0.8141	0.0055	%0.7
Adj R-Square	0.8127	0.0052	%0.6
StErr of Est	1.4276	-0.0195	-%1.3

ANOVA Table

Source	df	SS	MS	F	p-value
Explained	4	4472.8056	1118.2014	548.6610	0.0000
Unexplained	501	1021.0657	2.0381		

Regression coefficients

	Coefficient	Std Err	t-value	p-value
Constant	-10.5551	2.7470	-3.8424	0.0001
Turbidity	1.6679	0.0426	39.1249	0.0000
pH	2.5783	0.3611	7.1404	0.0000
Water temperature	0.1154	0.0224	5.1410	0.0000
electrical conductivity	0.0143	0.0037	3.8492	0.0001

The regression polynomial derived from the regression analysis is as follows.

▣ Coagulant injection rate = 1.66×Tb + 2.57×pH + 0.11×Wt + 0.01×Ec −10.55

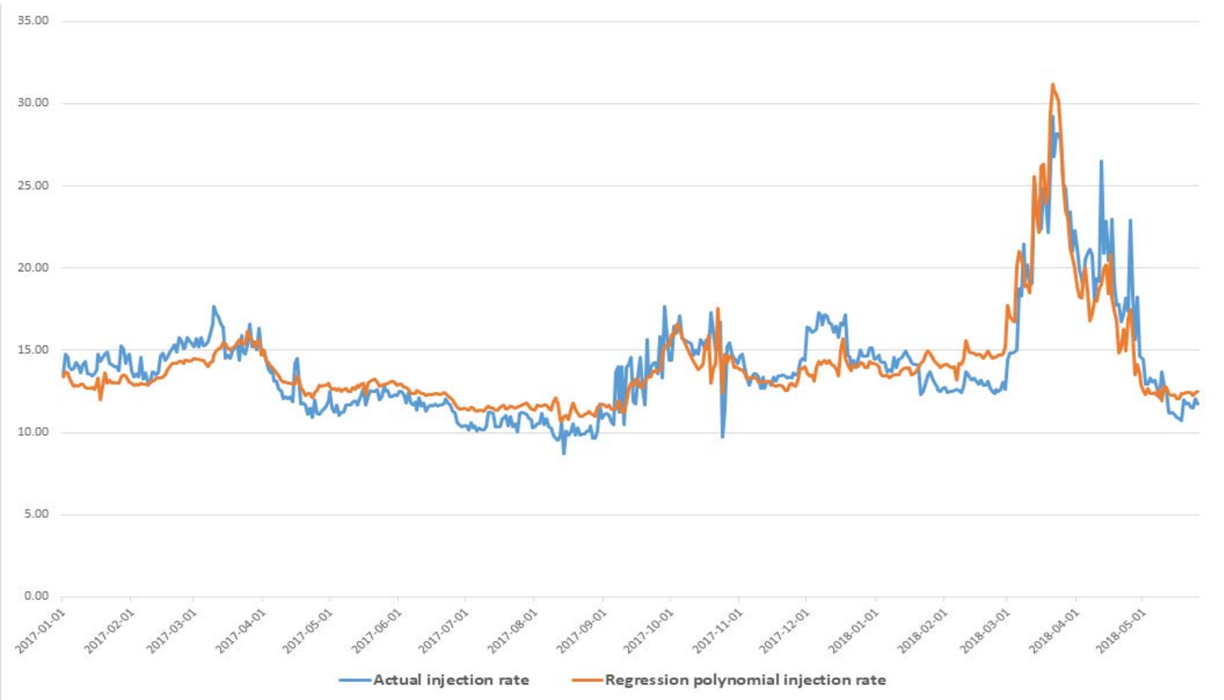
* Tb : Electrical conductivity

* Wt : Water Temperature

* Ec : Electrical conductivity

The R-Square value is 0.81 and the p-value is very low than the significance level (5%), which is 0.00. The above equation is statistically significant. The graph below compares the actual injection rate with the injection rate calculated by the regression polynomial. This enables the self-driving system of drugs to be established by automatically calculating the injection rate of compounds based on raw water quality. To build a more accurate system, it is necessary to apply artificial intelligence algorithms such as Support Vector Machines and ANN.

Figure 9. Comparative Analysis of Coagulant injection rate



3. Filtration Process

The filtration process is a key process for determining the quality of the water treatment process. The current operation method is to manually determine the operation index and the timing of the reverse cleaning by considering the distribution supply and water purification production. It is operated by an automated reverse washing program. Factors that determine filter operation include filter inflow and outflow, filter turbidity, loss of water, filter duration, drainage level, backwash bath level, and discharge process quality. The limitation of the current operation method is that the efficiency of the operation is low because the filter operation index and the backwash index are determined manually based on the experience of the workers.

It is necessary to build an autonomous operating system for the filtration process by an artificial intelligence algorithm and predicting the operation index according to the purified water volume and predicting the back-washing time. Artificial intelligence algorithms include forecasts of filter paper production and operating index in conjunction with recovery tank operating conditions and forecasts for backwash timing. Also, it is necessary to secure existing and new facility functions for operating the autonomous driving system.

	Input of control	Output of control	Process of big data analysis
❻ Optimal control of filter	Inflow/ Outflow, Valve status, Water level, Time of filter operation, Control priority Turbidity	Number of filter operation, Set value of outflow, Control signal of valve	Regression analysis,

4. Chlorine disinfection Process

The current method of operation of the disinfection process in the water purification plant is to manually determine the rate of residual chlorine and inject chlorine into the control of feedback or flow rate proportion according to the set values. The operator manually determines the chlorine injection rate in consideration of purified residual chlorine, CT value, inactivation ratio, and drainage residual chlorine. The limit of this current operation is that water quality accident is highly likely to occur because it cannot immediately respond to water change through manual determination of chlorine injection rate by man when water quality changes due to ammonia nitrogen, manganese or algae.

It is necessary to develop the chlorine injection rate prediction algorithm that can be operated immediately according to the water quality situation to solve this problem.

	Input of control	Output of control	Process of big data analysis
❹ Optimal control of chlorine	Inflow/ Outflow, Injector status, Water level, Residual chlorine, Control priority, CT value	Injection rate of chemical, Set value of chemical rate	Regression analysis

5. Supply process

The supply process is supplying purified water to the drainage through the pressurization plant after completing the water treatment process in the water treatment plant. The current operation method is operated by the human to manually determine the supply flow rate and control the related supply equipment remotely. Major operating factors include the level of the purified water storage, the level of the pressurization field, the level of the drain, the flow rate of the purified water storage, the flow rate of the purified water storage, the pressure of pump and pipeline, residual chlorine, and the turbidity. This method of operation has limitations such as inefficient energy management due to the limited acquisition of reservoir operation information.

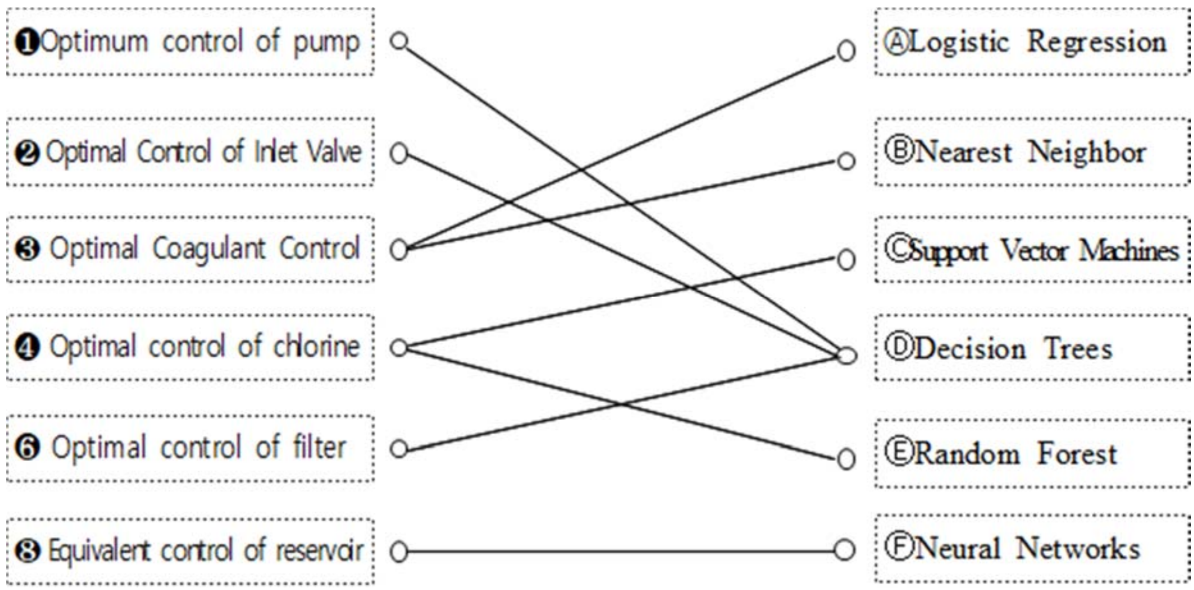
It is necessary to develop algorithms such as prediction of water demand and schedule for operation of supply facilities by the AI algorithms.

	Input of control	Output of control	Process of big data analysis
❽ Equivalent control of reservoir	Inflow/ Outflow, Pump status, Water level, Time of pump operation,	Number of pump operation, Pump control signal, Set value of flow,	Classification, Cluster, Regression analysis
❾ Pipe leak detection	Flow, Level of pressure	Pipe leak point, Valve control signal	Outlier detection

B. Application of optimal AI algorithm by element technology

In order to apply AI algorithm to element technology, it is classified by considering control factor, control method and data processing process. It is roughly classified into mixture, classification, analysis, and neural network analysis, and matching algorithms suitable for each control logic. Figure 10 shows application of optimal AI algorithm by element technology of water treatment process.

Figure 10. Application of optimal AI algorithm by element technology



IV. Recommendation of the Standard Model of Artificial Intelligence

The basic direction for introducing an artificial intelligence system in waterworks is proposed by establishing an open source-based customized platform. As shown in the table below, the open -source foundation is suitable for building a general-purpose platform as free software that can be continuously developed and is scalable in the future.

Table 6. Comparison Open-source and Dedicated Solution

		Open-source	Dedicated Solution
Universality		·Various languages functions	·Specific language functions
Extensibility		·Sustainable development	·Limited expansion according to development environment
Economics	Purchase cost	·Free use	·High cost of solution
	Construction cost	·Relative high cost	·Relative low cost
	Maintenance cost	·Low cost	·Annual fee based on contract with provider
Dependency		·Not dependent on a specific Company	·Dependent on solution holders
Global Trend		·Sustainable development in various fields	·Limited Use in some areas
kind		·Hadoop, tensorflow etc.	·SAS, FALKONRY etc.

The open-source base is suitable for building custom platforms for water treatment systems and has advantages in securing compatibility with existing systems.

V. Conclusion

This paper analyzed the limitations of the current operation of water intake, water purification, and water purification processes. It will be able to reduce production costs and upgrade the water treatment process technology to the next level and have a high-quality tap water production system by applying the artificial intelligence technology. In particular, the raw water quality and coagulant injection rate in the chemical process have a high correlation, and polynomials can be calculated through regression analysis.

It is possible to create a stable work environment with constructing a scientific system for producing high quality tap water, predicting water quality, and forecasting demand based on advanced operating technologies by developing and applying artificial intelligence (AI) technology to waterworks. Also, it will be able to secure technological competitiveness in the water industry and secure future growth engines in the water industry by securing intelligence information technology, which is key to the fourth industrial revolution.

However, there are some limitations in applying AI technology to water treatment processes at this time. First of all, big data analysis is essential to apply AI algorithm. Data quality management remains a very important task because data generated from sensors must be guaranteed integrity without false or missing data. In addition, it is necessary to apply artificial intelligence algorithms to the actual water treatment automatic control process.

Future researches will require verification of the proposed artificial intelligence technology in water treatment processes. Also, economic analysis through tangible and intangible empirical effects analysis before and after the introduction of an artificial intelligence system is necessary.

Artificial intelligence technology is still developing. The first thing we can do in the giant tide of artificial intelligence is to understand the evolution of technology and apply it effectively in our systems.

Bibliography

B. W. Kim, "Trend Analysis and National Policy for Artificial Intelligence," Informatization Policy, vol. 23, no. 1, pp.74-93, Mar. 2016.

D. E. Lee, "The 2017 STEPI International Symposium - Science and Technology Innovation, New 30 Years," Science and Technology Policy, vol. 226, pp. 46-51, May 2017.

S.H.Kim and S.H.Choi, "Exploratory Research on the Future Internet Policy according to the Changes in Korean Society," Internet and Information Security

H.I.Seok, "The Future of Smart Korea," Proceeding on International Conference of Information and Culture, 2010.

H. O. Choi, B. S. Choi, and S. G. Kim, "Policy and Implications of Japan's Fourth Industrial Revolution," Trends and Issues, no. 30, pp. 1-26, May 23, 2017.

H. O. Choi, "Japan's Future Investment Strategy 2017 Policy and Implications," Trends and Issues, no. 31, pp. 1-20, June 20, 2017.

W. H. Seok and K. H. Lee, "Possibility of artificial intelligence technology and industry," ETRI ECO T.E.A Issue Report, 2015-04, 2015.