2023 12th Mediterranean Conference on Embedded Computing (MECO)

including

11th International Conference on Cyber-Physical Systems and Internet-of-Things (CPS&IOT'2023)

Editors

Radovan Stojanović **Lech Jóźwiak**

Budimir Lutovac **Dražen Jurišić**

Proceedings – Research Monograph

June 6th – 10th, 2023, Budva, Montenegro

ISBN 979-8-3503-2291-0
IEEE Catalog Number: CFP2339T-ART

2023 12th Mediterranean Conference on Embedded Computing (MECO)

Part Number: CFP2339T-ART

ISBN: 979-8-3503-2291-0

Online ISSN: 2637-9511

Additional copies of this publication are available from

Curran Associates, Inc.
57 Morehouse Lane
Red Hook, NY 12571 USA

+1 845 758 0400
+1 845 758 2633 (FAX)

MECO 2023 covers:

- **MECO 2023 Conference**
- **CPS&IOT'2023 (11th International Conference on Cyber-Physical Systems and Internet-of-Things)**

For difficulty accessing documents, please contact the conference organizers
Email: meco.conference@gmail.com

Organizers, Sponsorships, Supporters

Organizers

University of Montenegro, Montenegro

Eindhoven Technical University

Faculty of Electrical Engineering, University of Montenegro, Montenegro

School of Electrical Engineering, University of Belgrade, Serbia

Faculty of Electrical Engineering and Computing, University of Zagreb, Croatia

Montenegrin Association for New Technologies **MANT**

Mediterranean Excellence in Computing and Ontology Institute **MECOnet**

Sponsorships

IEEE S&M Section

EuroMicro

Ministry of Science of Montenegro

Supporters/Sponsors

Čikom- Informatički Inženjering

Elcon d.o.o.

Industrial Systems Institute, Patras, Greece

European Comission via project from H2020 Programme

Committees

General Chairs

Radovan Stojanović, University of Montenegro, Montenegro
Lech Jóźwiak, Eindhoven University of Technology, The Netherlands

Research Chair

Veljko Milutinović, Fellow of the IEEE, Academia Europaea

Publication Chairs

Budimir Lutovac, University of Montenegro, Montenegro
Dražen Jurišić, University of Zagreb, Croatia

MECO and CPS&IOT Organizing Committee:

Dmitry Tarasov, MANT, Montenegro, Chair
Budimir Lutovac, University of Montenegro, Co-Chair
Podzharaya Natalia, RUDN University
Jovan Đurković, MECOnet
Denisa Kriještorac, MANT Montenegro
Matija Stojanović, MANT Montenegro

Scientific Committee | Editorial – MECO'2023

Yervant Zorian, Synopsys, USA
Thanos Stouraitis, Kalifa University, UAE
Srdjan Stankovic, University of Montenegro, Montenegro
Boualem Boashash, Qatar University, Qatar
Christos Koulamas, ISI, Patras, Greece
Milan Prokin, University of Belgrade, Serbia
Andrej Škraba, University of Maribor, Slovenia
Roberto Giorgi, University of Siena, Italy
Betim Cico, Epoka University Tirana, Albania
Gerhard Rath, University of Leoben, Austria
Milan Stork, University of West Bohemia, Czech Republic
Emil Jovanov, University of Alabama, USA
Roman Bazylevych, Lviv Polytechnic Univ., Ukraine
Ioannis Sourdis, Chalmers University, Sweden,
Jari Viik, Tampere University of Technology, Finland
Josep-Ramon Herrero, UPC Barcelona, Spain
Adam Postula, University of Queensland, Australia
Bilgin Metin, Bogazici University, Turkey
Miroslav Hagara, Slovak Technical University, Slovakia
Arda Yurdakul, Bogazici University, Turkey
Paris Kitsos, Hellenic Open University, Greece
Dražen Jurišić, University of Zagreb, Croatia
Almir Badnjević, University of Sarajevo, B&H
Anetta Caplanova, EUBA, Slovakia
Igor Djurović, Montenegrin Academy of Science and Arts, CANU, Montenegro
Sara Zermani, University of Brest, France
Gehad Alkady, The American University in Cairo, Egypt
Hana Kubatova, Czech Tehnical University Prague, Czech Republic
Zoya Dyka, Leibniz-Institut fuer innovative Mikroelektronik, Germany
Mustafa Engin, Ege University,Turkey
Sobhi Abou Chahine, Beirur Arab University, Lebanon
Alla Levina, LETI, Russia
Naim Dahnoun, University of Bristol, UK
John Galelis, University of Patras, Greece
Aphrodite Ktena, National and Kapodistrian University of Athens, Greece
Andrej Trost, University of Ljubljana, Slovenia
Zeev Zalevsky, Bar-Ilan University, Israel
Ivan Evgeniev Ivanov, Sofia Technical University, Bulgaria
Milica Orlandic, NTNU – Norwegian University of Science and Technology, Norway
Darko Babunski, Ss. Cyril and Methodius University, N. Macedonia
Emil Zaev, Ss. Cyril and Methodius University, North Macedonia
Maja Lutovac Banduka, Computer based systems RT-RK, Belgrade, Serbia
Mirjana Maksimović, University of East Sarajevo, B&H
Marko Bošković, University of East Sarajevo, B&H

Scientific Committee | Editorial – CPS&IOT'2022

***Program Chair*: Lech Jóźwiak,** TU Eindhoven, NL
***Manager Chair*: Radovan Stojanović,** University of Montenegro
Sajid Mohamed – ITEC B.V., NL
Ludovic Apvrille – Paris Telecom, FR
Neil Audsley, University of York, UK
Eesa Mohammed Bastaki, University of Dubai, AE
Jürgen Becker, Karlsruhe Institute of Technology, DE
Carlos T. Calafate,Technical University of Valencia, ES
Zlatan Car, University of Rijeka, HR
Anupam Chattopadhyay, Nanyang Technol. University, SG
Miguel Figueroa, Univesity of Concepcion, CL
Alberto L. Sangiovanni-Vincentelli, UC Berkeley, CA, US
Shiyan Hu, MTU, MI, US
Armando W. Colombo, Univ. Appl. Sci. Emden-Leer, DE
Masahiro Fujita, University of Tokyo, JP
Kris Gaj, George Mason University, US
Roberto Giorgi, University of Siena, IT
Raffaele Gravina, University of Calabria, IT
Ilker Hamzaoglu, Sabanci University, TR
Axel Jantsch, TU Wien, AT
Lech Jóźwiak, TU Eindhoven, NL
Mehdi Kargahi, University of Tehran, IR
Paris Kitsos, University of the Peloponnese, GR
Francesco Leporati, University of Pavia, IT
Jan Madsen, DTU, DK
Michail Maniatakos, NYU Abu Dhabi, AE
Onur Mutlu, ETH Zurich, CH
Alexandre S. Nery, Universidade de Brasília, BR
Jari Nurmi, Tampere University of Technology, FI
Roman Obermaisser, Siegen University, DE
Miroslav Pajic, Duke University, US
Sri Parameswaran, UNSW, AU
Luigi Pomante, UNIVAQ, IT
Peter Puschner, TU Wien, AT
Davide Quaglia, University of Verona, IT
Eric Rutten, INRIA Grenoble, FR
Max M. D. Santos, Federal University of Tech.Paraná, BR
Majid Sarrafzadeh, UCLA, California, USA
Muhammad Shafique, TU Wien, AT
Christoph Schmittner, AIT, AT
Chi-Sheng Shih, National Taiwan University, TW
Ioannis Sourdis, Chalmers Univ. of Technology, SE
Radovan Stojanović, University of Montenegro, ME
Andrej Škraba, University of Maribor, SI
Hiroyuki Tomiyama, Ritsumeikan University, JP
Martin Törngren, KTH, SE
Eugenio Villar, University of Cantabria, ES
Chao Wang, University of Sci and Technol. of China, CN
Guoqi Xie, Hunan University, CN
Arda Yurdakul, Bogazici University, TR
Yervant Zorian, Synopsys, US
Andrej Žemva, University of Ljubljana, Slovenia

Message from the Chairs and Editors

Dear Authors,

Dear MECO and CPSIoT Friends and Supporters,

Dear All,

When organizing The First Mediterranean Conference on Embedded Computing (MECO) in 2012, we did not hope that the conference would live that long and leave such a trace on science and technology in the Region and Worldwide. Today, we can no doubt say that MECO and the International Conference on Cyber-Physical Systems and Internet of Things (CPSIoT) have become the most prestigious events in their fields, even formally classified among the TOP conferences in Computer Sciences.

MECO and CPSIoT have always been organized in Montenegro, an amazing small Mediterranean country with pleasant people. This year, MECO will take place for its twelfth time, from June 6th to June 10th, 2023, in Budva, the pearl of the Mediterranean, one of the oldest settlements across the Adriatic coast, with documented references dating back to the 5th century BC, with golden beaches, refreshing sea breeze, and delicious Mediterranean cuisine.

This year's Programme is very rich. Despite the strict evaluation criteria, over 128 articles deserved to be selected. They are coming from about 50 countries, represented by about 200 institutions. This year we are especially happy to see the increased participation of our colleagues from the United States, Australia, New Zealand, and Japan. Therefore, MECO has no borders. At least, half of the papers belong to young researchers, who recognize MECO and CPSIoT as their chance, not only because of the quality but, also, because of our mission that young researchers, especially those from developing countries, should be able to publish their papers in high-quality but low-cost publications so as to permanently foster their academic and professional growth. In addition to numerous papers, four outstanding keynotes, project dissemination, company exhibitions, round tables, demo sessions, etc will reinforce our events.

Traditionally, MECO and CPSIoT represent twin events co-organized and supported by numerous institutions, among others IEEE, EUROMICRO, MANT, MECOnet, University of Montenegro, Eindhoven Technical University, University of Zagreb, University of Belgrade, Industrial Systems Institute, Ministries of Montenegro, Čikom, Elkon, Industrial Systems Institute, European projects and by other, no less significant institutions. The 3rd Summer School on Cyber-Physical + Systems and Internet of Things (SS-CPS&IoT) continues to grow, having more than 80 students and presenters, from over 20 countries. This School is an example of our commitment to fusion research, education, and training

MECO’2023 and CPSIoT’2023 run in 15 thematic areas: Keynotes; Cyber-Physical Systems and Internet of Things – CPSIoT’2023; Hardware and Applications; Software and Applications, DSP and AI with Applications; Communications and Networks; Control, Robotics, Sensors, and Measurements; Embedded systems in Biomedical Engineering and Health Care; Education in Electrical Engineering; Energy and Embedded Computing; Smart Systems for All – SMART4ALL; Related fields; Companies; Project Dissemination and Works in Progress. Sections are further divided into Sessions; the total number of sessions is over 30, during the four days of the conference. Works are presented in-venue and online. Our conferences never forget the social component, so a rich social program is organized. We are especially glad if the participants find time to visit some of the beauties of Montenegro.

What achievement makes us feel so proud of? Undoubtedly, it is the MECO Proceedings, which have been indexed in prestigious Databases: IEEE Xplore, SCOPUS, Web of Science (WoS), DPLB Computer Science Bibliography, SJR-SCimago Journal & Country Rank, Microsoft Academic, Schematic Scholar, Google Scholar, Research Gate, etc., as well as by numerous regional and university digital libraries, and all these internationally recognized databases significantly expand the citation rate of our papers.

A high-quality MECO and CPSIoT academic program would not have been possible without the contribution of authors, keynote speakers, organizers, student volunteers, and more than 400 reviewers who have been working very diligently to prepare documents and presentations, establish conference infrastructure, and produce relevant materials. We are very grateful to them.

Ensuring a high-quality level would have been impossible without the support of IEEE, Serbia, and Montenegro Section, the international umbrella organization for embedded computing and wider electrical and computer engineering. By organizing MECO, the Montenegrin Association of New Technologies – MANT and vibrant innovative spin-off MECOnet, have shown a new way of knowledge dissemination, sharing, and promotion, giving proof that this mission is not only a privilege of the Big.

In the end, we would like to extend our thanks to all enthusiastic colleagues from the Organizational and Scientific Committee as well as to our sponsors and supporters.

We wish all participants an excellent conference, good health, personal and family happiness, and career success.

Have a happy 12th MECO, 11th CPSIoT, and 4th Summer Scholl on CPS&IoT!!!

Your chairs,

Radovan Stojanović, Chair
University of Montenegro, Montenegro

Lech Jóźwiak, Chair
Eindhoven University of Technology,
The Netherlands

Budimir Lutovac, Publication Chair
University of Montenegro, Montenegro

Dražen Jurišić, Publication Chair
University of Zagreb, Croatia

Contents

Use of Reinforcement Learning in the Modeling of Ring-Type Water Networks

Aleksandar Buchkovski, Zoran Markov, Viktor Iliev, Darko Babunski
Department of Hydraulic Engineering and Automation,
Faculty of Mechanical Engineering
University St. Cyril and Methodius
1000 Skopje, North Macedonia
abuckovski@gmail.com

Abstract. In this paper it is proposed to use reinforcement learning (RL) based predictive control of ring-type water supply network for finding the optimal path from point of water supply to point of water consumption avoiding some obstacles that may arise along the way. An example of an obstruction may be a defect in a section point (consumer) through which the water cannot flow. Ring-type water supply network consists of a number of closed rings surrounding the consumers while supplying them with water through sections. In this paper, a computer program was developed in LabVIEW in order to calculate the optimal path from point of water supply to point of water consumption based on reinforcement learning techniques. In order to achieve the goal, Markov Decision Processes, Q-Learning, Bellman Equations and Policy Gradients were used. The results show the optimal path.

Keywords: *Reinforcement learning, LabVIEW, Ring-type water supply networks.*

I. INTRODUCTION

The fact that water, along with energy and food, is one of the three major interrelated global environmental security issues, presents a wealth of challenges and opportunities for applying machine learning to problems such as optimizing water supply planning and operations, modelling and forecasting. Advances in geographic information systems (GIS), remote sensing and weather forecasting techniques, demonstrate that environmental data is becoming more widely available, while at the same time the demand for solutions and tools to address these problems are becoming more urgent.

The idea that we learn by interacting with our environment is probably the first to occur to us when we think about the nature of learning. When an infant plays, waves its arms or looks around, it has no explicit teacher, but it does have a direct sensorimotor connection to its environment. Exercising this connection produces a wealth of information about cause and effect, about the consequences of actions, and about what to do in order to achieve goals. Throughout our lives, such interactions are undoubtedly a major source of knowledge about our environment and ourselves. Whether it is about learning to drive a car or to hold a conversation, we are acutely aware of how our environment responds to what we do, and we seek to influence what happens through our behaviour. Learning from interaction is a foundational idea underlying nearly all theories of learning and intelligence [1].

Continuous on-line monitors and sensors are increasingly being used to measure a wide range of potable water hydraulic and quality variables within water distribution systems (WDS). The proliferation and diminishing costs of automated data transfer, such as by SMS and GPRS systems, is allowing all types of recorded data to be transferred from many disparate points on the networks. Water utilities are struggling to archive or to transform the data effectively into knowledge with which to enable operational control. Data-driven modelling provides a mapping between the inputs and outputs of a given system, with the advantage of not requiring a detailed understanding of the physical, chemical and/or biological processes that affect a system – and it is emerging as an attractive option for prediction and classification in water systems. Data-driven models can complement and sometimes replace deterministic models and reinforcement learning offers one such model. Reinforcement learning has been successfully applied to a range of water modelling problems and has displayed particular promise for forecasting applications. They can be evaluated based on physical model outcomes and experimental/field data can be further integrated in order to enhance their performance [2].

Sensor data (such as flow or pressure) obtained from a WDS is in the form of a time series—that is, a data stream consisting of one or more variables whose value is a function of time. Due to opportunities afforded in recent years, near real time data acquisition is enabling new applications to be developed utilising this data. The challenge for data-driven approaches is to learn and predict the normal variability of a particular time series and then use this in areas such as demand forecasting or abnormality detection.

II. REINFORCEMENT LEARNING IMPLEMENTATION

Q-learning is a widely used model-free reinforcement learning algorithm that learns an optimal action-value function

979-8-3503-2291-0/23/$31.00 ©2023 IEEE

by iteratively updating Q-values based on the observed rewards and transitions. The Q-values represent the expected return the agent can obtain by taking a particular action in a given state, and they are used to derive the optimal policy.

Q-tables are a simple and effective way to implement Q-learning in discrete state and action spaces. However, they have several limitations in practice, such as the exponential growth of the table size with the number of states and actions, the inability to generalize to unseen states and actions, and the susceptibility to overfitting and data sparsity.

One approach to solve this problem is to use function approximation to estimate the Q-values based on a set of features that capture the relevant aspects of the state and action spaces. Function approximation can reduce the memory and computational requirements and generalize to unseen states and actions, but it can also introduce biases and approximation errors.

This technique of Q-tables was used in this research. A small ring-type water supply network with 9 nodes was used that represent water consumers. Looking at the following environment, the agent in the environment is the water. The agent wants to find its way in the least amount of time to its final destination without stumbling across a consumer to avoid, which will, itself, waste all the water.

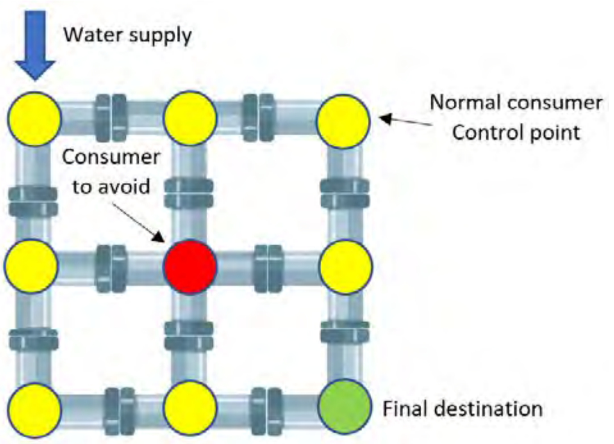

Fig. 1 Ring-type water network environment

The agent can flow left, right, up or down in this environment. These are the actions. The states are determined by the individual tiles and where the agent is on the board at any given time. If the agent lands on a normal consumer, the reward is 0 points. Reaching the final destination is +10 points and will end the episode. Landing at the consumer to avoid is -10 points and will also end the episode.

TABLE I
States and Rewards

State	Reward
Normal consumer	0 points
Final destination	+10 points episode over
Consumer to avoid	-10 points episode over

At the start of the process, the agent has no knowledge of how efficient any given action is from any given state. It's only aware of the current state of the environment. In other words, it doesn't know from the start whether navigating left, right, up or down will result in a positive or negative reward. Therefore, the *Q*-values for each state-action pair will all be initialized to zero since the agent knows nothing about the environment at the start. Throughout the process of learning, the *Q*-values will be iteratively updated using value iteration.

A *Q*-table will be used, to store the *Q*-values for each state-action pair. The horizontal axis of the table represents the actions, and the vertical axis represents the states. The dimensions of the table are the number of actions by the number of states.

TABLE II
Q-Table

		Actions			
		Left	Right	Up	Down
States	Normal consumer	0	0	0	0
	Normal consumer	0	0	0	0
	Normal consumer	0	0	0	0
	Normal consumer	0	0	0	0
	Consumer to avoid	0	0	0	0
	Normal consumer	0	0	0	0
	Normal consumer	0	0	0	0
	Normal consumer	0	0	0	0
	Final destination	0	0	0	0

All the *Q*-values in the table are first initialized to zero, since the agent knows nothing about the environment or the expected rewards for any state-action pair. Over time, as the agent plays several episodes of the game, the *Q*-values produced for the state-action pairs that the agent experiences will be used to update the *Q*-values stored in the *Q*-table. As the *Q*-table becomes updated, in later moves and later episodes, the agent can look in the *Q*-table and base its next action on the highest *Q*-value for the current state.

In each episode, the agent starts out by choosing an action from the starting state based on the current *Q*-values in the table. The agent chooses the action based on which action has the highest *Q*-value in the *Q*-table for the current state. That's unusual for the first actions in the first episode. Because all the *Q*-values are set zero at the start, there's no way for the agent to differentiate between them to discover which one is considered better. So, what action does it start with? To answer this question, the trade-off between exploration and exploitation is introduced.

In reinforcement learning, the exploration-exploitation trade-off refers to the balance between trying out new actions to gain more knowledge about the environment (exploration) and exploiting the current knowledge to maximize the expected reward (exploitation).

In order to determine whether the agent will choose exploration or exploitation at each time step, in the research it is generated a random number between 0 and 1. If this number is greater than epsilon, then the agent will choose its next action via exploitation, i.e. it will choose the action with the highest *Q*-value for its current state from the *Q*-table. Otherwise, its next action will be chosen via exploration, i.e. randomly choosing its action and exploring what happens in the environment.

The Bellman equation is used to update the *Q*-value for the action of the movement taken from the previous state. The formula for calculating the new *Q*-value for state-action pair *(s, a)* at time *t* is as follows:

$$q^{new}(s, a) = (1 - \alpha)\, q(s, a) + \alpha(R_{t+1} + \gamma\, max_{a'}\, q(s', a'))$$

The new *Q*-value is equal to a weighted sum of the old value and the learned value. This new *Q*-value is taken and stored in the *Q*-table for this particular state-action pair. This same process will occur for each time step until termination is reached in each episode. Once the *Q*-function converges to the optimal *Q*-function, the optimal policy is achieved.

III. RESULTS AND DISCUSSION

A. States and Actions Q-Table

For all possible states, all possible actions were chosen (as shown in Fig. 3):

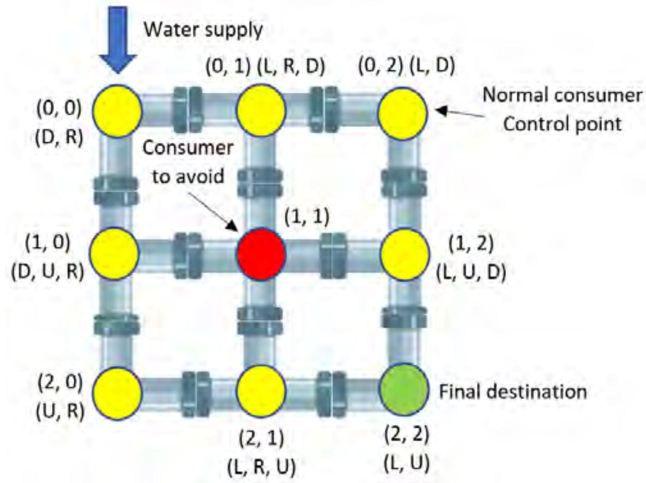

Fig. 2 Position of the states in the environment

According to the environment, the following State – Action pairs Q-Table was created:

TABLE III
State-Action Q-Table

States	Actions			
	Left	Right	Up	Down
(0, 0)		X		X
(0, 1)	X	X		X
(0, 2)	X			X
(1, 0)		X	X	X
(1, 1) final destination	-	-	-	-
(1, 2)	X		X	X
(2, 0)		X	X	
(2, 1)	X		X	X
(2, 2) final destination	-	-	-	-

It should be noted that when the agent reaches his final destination (final state) there is no action to be taken.

B. Q-Learning Parameters

For the calculation the following Q-Learning Parameters were used:

- number of episodes = 10000,
- maximal steps per episode = 100,
- learning rate $\alpha = 0{,}7$,
- discount rate $\gamma = 0{,}99$,
- starting exploration rate = 1,
- minimum exploration rate = 0,01,
- exploration rate decay = 0,001.

C. Rewards

If the agent lands on an empty tile, the reward is zero points. A tile with final destination is plus ten points and will end the episode. A tile that states 'consumer to avoid' is minus ten points and will also end the episode. All rewards are listed in the table below.

TABLE IV
Rewards

0	0	0
0	-10	0
0	0	+10

D. Results

After 10000 episodes played, the updated Q-Table looks like shown below:

TABLE V
Q-Table Results

States	Actions			
	Left	Right	Up	Down
(0, 0)	0	9,70	0	9,51
(0, 1)	9,61	9,80	0	-10
(0, 2)	9,70	0	0	9,90
(1, 0)	0	-10	9,61	9,41
(1, 1) final destination	0	0	0	0
(1, 2)	-10	0	9,80	10
(2, 0)	0	9,51	9,51	0
(2, 1)	9,41	0	-10	9,61
(2, 2) final destination	0	0	0	0

With green are highlighted the values of the optimal policy (solution). The optimal path from point of water supply to point of water consumption avoiding the obstacle along the way can be visually seen on the picture below. What is also interesting to notice from the results of the Q-Table is that the values increase as the goal is approached. This is a result of the Bellman optimality equation. As we approach the goal the agent is confident about its decisions. This algorithm was coded and developed in LabVIEW from scratch.

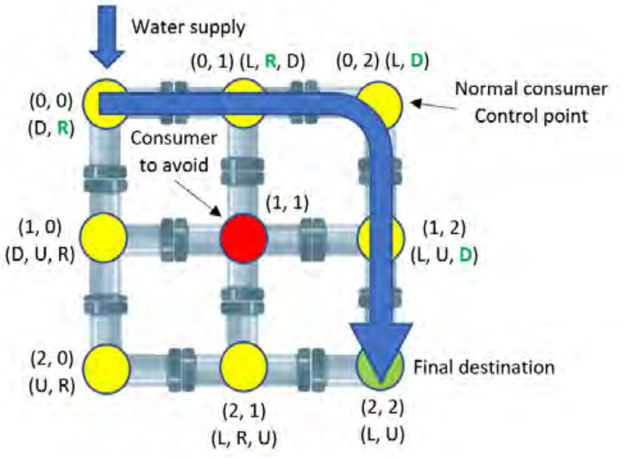

Fig. 3 Optimal path (policy)

IV. CONCLUSIONS

The existing control of ring-type water supply networks focused mainly on manual operation of the systems. Optimization approaches repeatedly solving optimization problems and data-driven predictive control based on reinforcement learning can compensate the weakness of manual operation of the systems. In this study, it was designed a reinforcement learning (RL) based predictive control.

In this paper, RL agent was utilized based on model-free algorithm to efficiently finding the optimal path from point of water supply to point of water consumption avoiding some obstacles that may arise along the way. Model-free algorithms gradually search for an optimal policy through exploration and exploitation and require a lot of training samples to find a proper policy, compared to model-based algorithms.

REFERENCES

[1] Richard S. Sutton, Andrew G. Barto (2018): *Reinforcement learning: an introduction*, Cambridge, MA: The MIT Press.

[2] Stephen Mounce (2013): *A comparative study of artificial neural network architectures for time series prediction of water distribution system flow data,* Machine Learning in Water Systems, pp. 5–12.

[3] Chris and Mandy (2017): *https://deeplizard.com/*, https://deeplizard.com/learn/video/my207WNoeyA

[4] Chris and Mandy (2017): *https://deeplizard.com/*, https://deeplizard.com/learn/video/a-SnJtmBtyA

[5] Chris and Mandy (2017): *https://deeplizard.com/*, https://deeplizard.com/learn/video/eMxOGwbdqKY

[6] Chris and Mandy (2017): *https://deeplizard.com/*, https://deeplizard.com/learn/video/rP4oEpQbDm4

[7] Sam Charrington: *Artificial Intelligence for Industrial Applications,* CloudPulse Strategies

[8] Klaus Ahlborn, Gerd Bachmann, Fabian Biegel, Jörg Bienert, Prof. Dr. Svenja Falk, Prof. Dr.-Ing. Alexander Fay, Dr. Thomas Gamer, Kai Garrels, Dr.-Ing. Jürgen Grotepass, Dr. Andreas Heindl, Jörg Heizmann, Claus Hilger, Dr. Martin Hoffmann, Dr. Michael Hoffmeister, Michael Jochem, Johannes Kalhoff, Martin Kamp, Prof. Dr. Stefan Kramer, Dr. Bernd Kosch, Christoph Legat, Dr. Jan Stefan Michels, Dr. Alexander Mildner, Dr. Andreas Nettsträter, Rohitashwa Pant, Dr. Reinhard Pittschellis, Thomas Schauf, Dr. Hans-Jürgen Schlinkert, Dr. Marco Ulrich, Guido Zinke (2019): *Artificial Intelligence in Industrie*

[9] Siamak Talatahari, Shengyong Chen, Amir H. Gandomi, and Amir H. Alavi (2014): *Advances of Artificial Intelligence in Mechanical Engineering*

[10] Qi Huang (2017): *Application of Artificial Intelligence in Mechanical Engineering*, Advances in Computer Science Research, volume 74

[11] S.Anush Lakshman, D.Ebenezer (2020): *Application of principles of a Artificial Intelligence in Mechanical Engineering*, 3rd International Conference on Advances in Mechanical Engineering (ICAME 2020)

[12] John R. Dixon (1986): *ARTIFICIAL INTELLIGENCE AND DESIGN: A MECHANICAL ENGINEERING VIEW,* AAAI-86 Proceedings

[13] Rainer Glatz, Kai Peters (2018): *Artificial Intelligence in Mechanical Engineering - Perspectives and Recommendations for Action,* European Office VDMA

[14] Saquib Rouf, Moonis Ali, Ali Hussain (2018): *Artificial Intelligence in Mechanical Engineering,* IJSRCSEIT | Volume 4 | Issue 1 | ISSN : 2456-3307

[15] Anđela Kovačević; Azemina Lakota; Lamija Kuka; Ervina Bečić; Alisa Smajović; Lejla Gurbeta Pokvić (2022): *Application of Artificial Intelligence in Diagnosis and Classification of Anemia*, 11th Mediterranean Conference on Embedded Computing (MECO)

[16] Amna Ćutahija; Adna Džemat; Romana Mandić; Alisa Smajović; Ervina Bečić; Fahrir Bečić; Almir Badnjević (2022): *Application of artificial intelligence in the diagnosis of pulmonary emphysema*, 11th Mediterranean Conference on Embedded Computing (MECO)

[17] Nejira Vehabović; Amina Zaimović; Faris Trako; Fahir Bečić; Alisa Smajović; Amar Deumić (2022): *Use of Artificial Intelligence for Identification of Increased Risk of Osteoporosis Development in Postmenopausal Women*, 11th Mediterranean Conference on Embedded Computing (MECO)

[18] Jens Bielefeldt; Basener Kai-Uwe; Siddique Reza Khan; Mozhdeh Massah; Wiesbrock Hans-Werner; Stefan Scharoba; Michael Hübner (2021): *DeepTest: How Machine Learning Can Improve the Test of Embedded Systems*, 10th Mediterranean Conference on Embedded Computing (MECO)