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CHANGING KAZAKHSTAN SOCIETY USING SMART TECHNOLOGIES

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Abstract: *The duty of a citizen, as you know, is considered to serve in the army, but it does not end only with it. A citizen is obliged to report violations of the law and to adhere to the rules and laws of the country. We are talking about the broad responsibilities of the citizen, which form the society, civil society. Kazakhstan as a developing country requires the improvement of civil society, increasing the responsibility of each citizen to raise the importance of the laws of the country. To do this, there are many tools and institutions that require large investments, and they have many flaws. The application can also help spend fewer resources and to modernize civil society effectively. Compared to traditional applications with simple algorithms, a machine learning application has more advantages, it helps to recognize the violation of the law without an intermediary such as human and is more effective in data processing and further analysis. In this article, we presented a new approach to the education of citizens with minimal expenditure of resources of the country, effective encouragement of users of the program "PhotoFact" and punishment of violators of the laws. The application "PhotoFact" registers several types of violation of the rules of Parking SDA RK, and only the smartphone of the user who downloaded this application is needed. An important role is played by the network of users of this application and their civil liability. The model "Faster R-CNN Inception v2" is used for recognition of transport, road signs, transport number, location features. This model facilitates the recognition of objects due to the large database and the speed of recognition.*

Keywords: *CNN - Convolutional Neural Network (convolutional neural networks), R-CNN - Regions with CNN (convolutional neural networks based on individual regions), Faster R-CNN (accelerated R-CNN model)*

"АҚЫЛДЫ" ТЕХНОЛОГИЯЛАРДЫ ПАЙДАЛАНА ОТЫРЫП, ҚАЗАҚСТАНДАҒЫ ҚОҒАМДЫ ӨЗГЕРТУ

Аңдатпа: *Азаматтың міндеті – әскерде қызмет ету болып саналады, бірақ бәрі мұнымен аяқталмайды. Азамат заңның бұзылуы туралы хабарлауға және елдің ережелері мен заңдарын ұстануға міндетті. Әңгіме азаматтың әлеуметтік, азаматтық қоғамды қалыптастыратын міндеттері туралы болып отыр. Қазақстан дамушы ел ретінде азаматтық қоғамды жақсартуды, ел заңдарының маңыздылығын көтеру үшін әрбір азаматтың жауапкершілігін арттыруды қажет етеді. Ол үшін үлкен салымдарды талап ететін көптеген құралдар мен институттар бар, сондай-ақ олардың көптеген кемшіліктері бар. Қосымша аз ресурстармен жұмыс істеуге және азаматтық қоғамды неғұрлым тиімді жаңғыртуға көмектесе алады.*

Қарапайым алгоритмдері бар дәстүрлі қосымшалар мен салыстырғанда, машиналық оқытумен қосымшалар көбірек артықшылықтарға ие болады, өйткені заңды бұзуды делдалсыз адам түрінде тануға көмектеседі және деректерді өңдеумен одан әрі талдауда неғұрлым тиімді. Мақалада ел ресурстарының аз шығынымен, «PhotoFact» бағдарламасын пайдаланушыларды тиімді көтермелеумен және заң бұзушыларды жазалаумен азаматтарды тәрбиелеуде жаңа көзқарасты ұсындық. «PhotoFact» қолданбасы ҚРЖҚ Ережелерін бұзудың бірнеше түрін тіркейді, бұл ретте осы қосымшаны жүктеп алған пайдаланушының смартфоны ғана қажет. Өз кезіндегі қосымшаны пайдаланушылар желісі мен олардың азаматтық жауапкершілігі маңызды рөл атқарады. Біз қайтадан велосипед ойлап шығармаймыз және бұрын болмағанды жаңадан ойлап таппаймыз, керісінше, Қазақстанда бұрын пайдаланылмаған модельдер мен жүйелерді ұсынғандықтан, соны пайдаланамыз. Көлікті, жол белгілерін, көлік нөмірін, локация ерекшеліктерін тану үшін «Faster R-CNN Inception v2» моделі пайдаланылады. Аталған модель кең деректер базасымен тану жылдамдығының арқасында

объектілерді тануды жеңілдетеді. Бұдан әрі мейлінше, осы қосымшада қолданылған барлық құралдарды және оларды тестілеу нәтижелерін егжей-тегжейлі сипаттаймыз.

Түйінді сөздер: *CNN - convolutional neural network (нейрондық желілер), R-CNN - Regions with CNN (жекелеген аймақтарда негізделген нейрондық желілер), Faster R-CNN (жедел R-CNN моделі)*

ИЗМЕНЕНИЯ В ГРАЖДАНСКОМ ОБЩЕСТВЕ КАЗАХСТАНА ЧЕРЕЗ «УМНЫЕ» ТЕХНОЛОГИИ

Аннотация: *Обязанностью гражданина, как ведомо, считается служение в армии, но все на этом не заканчивается. Гражданин обязан сообщать о нарушениях закона и сам придерживаться правил и законов страны. Речь идет о широких обязанностях гражданина, которые и формируют социум, гражданское общество. Казахстан как развивающаяся страна требует улучшения гражданского общества, повышение ответственности каждого гражданина для поднятия значимости законов страны. Для этого существуют много инструментов и институтов, требующих больших вложений, а также имеется много изъянов. Приложение же может помочь обойтись меньшими ресурсами и более эффективно модернизировать гражданское общество. По сравнению с традиционными приложениями с простыми алгоритмами, приложение с машинным обучением имеет больше преимуществ, поскольку помогает распознавать нарушение закона без посредника в виде человека и более эффективен в обработке данных и дальнейшего анализа. В этой статье мы представили новый подход в воспитании граждан с минимальными тратами ресурсов страны, эффективным поощрением пользователей программы "PhotoFact" и наказанием нарушителей законов. Приложение "PhotoFact" регистрирует несколько типов нарушений правил парковки ПДД РК, при этом нужен лишь смартфон пользователя, скачавшего данное приложение. Немаловажную роль при этом играет сеть пользователей данного приложения и их гражданская ответственность. Мы не изобретаем снова велосипед и не придумываем что-то, чего раньше не существовало, наоборот применяем существующие модели и системы ранее неиспользованных именно так, как представляем в Казахстане. Для распознавания транспорта, дорожных знаков, номера транспорта, особенностей локации используется модель "Faster R-CNN Inception v2". Данная модель упрощает распознавание объектов благодаря широкой базе данных и скорости распознавания. Далее подробно описываются все инструменты, использованные в данном приложении и результаты их тестирования.*

Ключевые слова: *CNN – convolutional neural network (сверточные нейронные сети), R-CNN - regionswith CNN (сверточные нейронные сети, основанные на отдельных регионах), Faster R-CNN (ускоренная модель R-CNN)*

INTRODUCTION

At the heart of the behaviour of criminals lies impunity for the inability to recognize the person, they cease to respect the laws and even in the case of capture, can escape responsibility through corruption. Application "PhotoFact" sets several tasks to be solved. The problem of recognizing the offender's transport should include the identification and vetting of committed violations by Parked vehicles. The system identifies an unknown vehicle, location of the alleged violation with the help of GPS, the date and time. On the basis of data of law enforcement agencies, the identity of the owner of the car is automatically established, whereas, in the existing system of identification, the intermediary like a police officer can not give out the name of the owner because of corruption components or lack of knowledge. Covering such loopholes in the law enforcement system will force society, regardless of status, to approach the issue of Parking their vehicles more carefully, because an anonymous user of the application can easily register a violation, which will always keep the car owner in suspense.

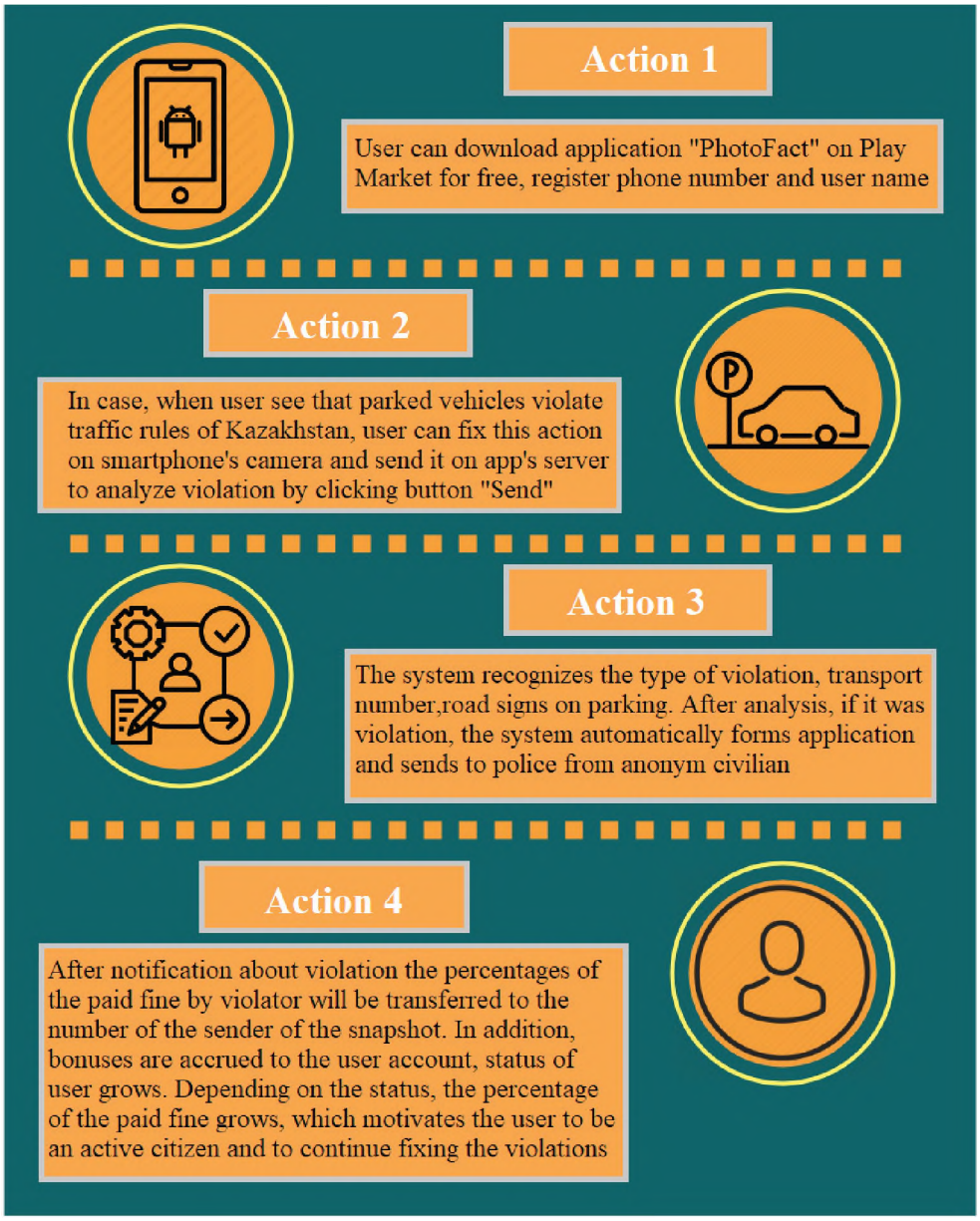

Figure 1 – The principle of the application "PhotoFact"

ANALYSIS OF PROBLEMS AND SIMILAR SOLUTIONS

The key advantages of the system are its low cost, for this system does not need to hire a large staff, the application is downloaded free of charge to any smartphone on the Android platform. According to the TNS Infratest survey commissioned by Google in 2016, 65% of Kazakhstanis were smartphone users, this figure is one of the highest in the post-Soviet space, which shows the wide coverage of the country's population in the case of its release on smartphones [1].

In addition to the low cost of the system "PhotoFact", it can bring large amounts of income to the budget of the country, with the deduction of expenditure will give new resources for development. As the statistics of 2017 shows the collection of administrative fines and other penalties presented by the multimedia information and analytical portal informburo.kz it amounted to 26.7 billion tenge [2], budget revenues from fines is one of the main sources of non-tax revenues that in the future go to the construction of

schools, salaries and much more. Citizens should be aware that they are doing a great job not only for themselves but also for the life of the country.

In addition, as practice shows, the establishment of cameras in the North Kazakhstan region has significantly reduced the number of offences on the assurance of the Deputy head of the district police Department Zhaslan Kasenov. The guards managed to detain 78 criminals, which creates a safe society [3]. The project "Sergek" allowed to reduce the crime rate in the capital by 24%, the official website of the mayor's office of Nur Sultan reports. In addition, the project has improved safety on the roads of the capital. Drivers have become more disciplined, which favourably affected the accident rate. At the end of last year, the death rate on the roads in Nur Sultan almost halved compared to 2017. The death rate on the roads in the capital is 3.1 per 100 thousand people, which is more than 3.5 times lower than in the country. With the help of "smart" video cameras in the city recorded more than 700 thousand offences totalling 5 billion tenge, and the budget received about 3 billion tenge, this was reported on the website of the mayor's office of Nur Sultan [4].

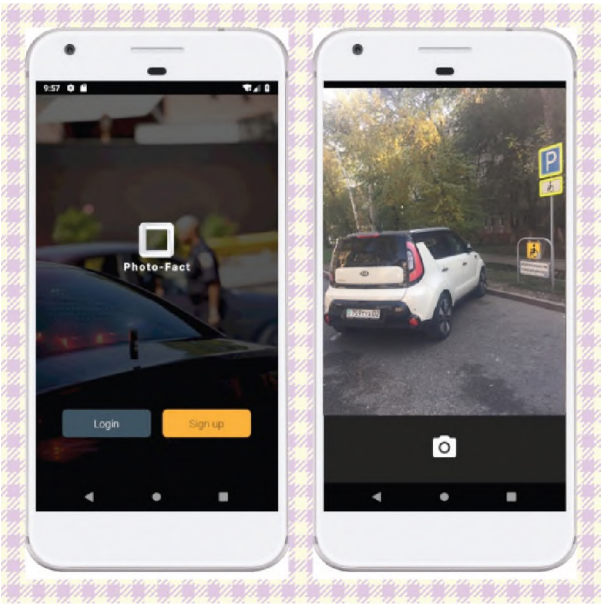

Figure 2 – Interface Template

Similar work is done to change the behaviour of the society of drivers and driving culture in Kazakhstan with the help of the system "Sergek" since 2014, based on the neural network. As described earlier in the report of the mayor's office of Nur Sultan, this system has given a lot of positive changes in the behaviour of drivers where the "Sergek" cameras were installed [4], but this system is not effective in places not convenient for the installation of cameras and this project has a high cost and maintenance. For example, on July 20, 2017, the deputies of maslikhat of Nur-Sultan unanimously voted for the decision to install 13,000 cameras in the capital under the PPP program, the cost of the project was determined at 8.4 billion tenge with a contract for 6 years 7 months [5].

SUGGESTED APPROACH

The recognition methods offered by "PhotoFact" are cheaper and easier. Object recognition is divided into three main methods: structural, statistical and neural network. Like "Sergek" application "PhotoFact" uses a neural network method. Except for social problems which application can solve, there will be demonstrated technical solutions and models.

Structural methods are aimed at images of objects and are applied to tasks in which information about the structure of each object is important. Underway implies a series of signs of. Each image belongs to the class. A class is an object with the same images. Three feature representations are used to classify images: vector, character string, and feature tree. From the structural recognition, the method is required to determine the object and its class and find information that does not define it to another class. The most common use of structural recognition is the task of classifying characters, letters of the alphabet or numbers. These tasks have different typefaces, but they are the same character.

Statistical recognition methods rely on classification rules. This method is used in problems in which the probability of occurrence of each class is known. Statistical recognition methods are used when all parameters such as height, width, and area are known to detect pattern similarity.

Neural networks are an actively developing alternative to traditional methods of recog-

nition. Artificial neural networks are mathematical models built on the principle of biological neural networks of living organisms. The neural network method is suitable for problems with unknown patterns. Learning from different examples, a neural network can solve problems with known patterns and dependencies between input and output data. Traditional methods cannot cope with such tasks. Also, the main advantage of neural networks is the speed and adaptation to changes in the weapon environment. That is, the neural network can be retrained in real time. Neural networks for image and object recognition are divided into three types:

1. Single-layer neural networks are used for classification tasks using the frequency characteristics of the entire image.

2. Multilayer neural networks are used for tasks in which the input is supplied by the image itself or a set of extracted characteristics, the output of the neuron indicates belonging to the class. The flaw of this type is the increase in the time of training and work with an increase in the number of classes.

3. Convolutional neural networks are arranged like the visual cortex of the brain are able to concentrate on a small area and highlight important features in it, but also one of the important flaws is that it is not clear for what task and computing power what settings are needed [6].

In this article, we decided to use the "Faster R-CNN Inception v2" model. This model has excellent results both in speed and in the definition of objects. As a basis, it was decided to use the TensorFlow API. The TensorFlow API allows you to visualize the results in the form of restrictive frames as object frames, and also allows you to monitor the results of neural network training.

Faster R-CNN is a model adapted for object detection tasks. Since CNN performed well in image classification, the R-CNN model was created to improve the accuracy and speed for the recognition and classification of objects and images. In R-CNN, the image is sent to the input via the regions previously selected in another way, on which objects can be located. At the moment there is an improved version of the model. R-CNN, Faster R-CNN which became much faster and began to more accurately recognize objects.

In faster R-CNN, training of the model involves four steps. The first two steps train the Region Proposal Network (RPN) and the detection network, minimizing the loss and obtaining the weights and biases. The final two steps combine the results of the pre-trained networks, fusing the parameters of a single network for detection and classification. All the steps use Stochastic Gradient Descent with Momentum (SGDM) as the optimization algorithm for training.

$$\theta\ell + 1 = \theta\ell - \alpha\nabla E(\theta\ell) + \gamma(\theta\ell - \theta\ell - 1) \quad (1)$$

where ℓ corresponds to iteration number, $\alpha > 0$ is the learning rate, θ is the parameter vector (weights and biases) and $E(\theta)$ is the loss function. The stochastic component corresponds to the evaluation of the gradient and the updates of parameters using a subset of the training set. Each evaluation of the gradient using the mini-batch is an iteration. At each iteration, the algorithm takes one step towards minimizing the loss function. The full pass of the training algorithm over the entire training set using mini-batches is an epoch. The momentum term γ determines the contribution of the previous gradient step to the current iteration and is used to avoid oscillation along steepest descent to the optimum. The learning rate of the two first steps is larger (1e-5 vs 1e6) since the first layers require faster convergence, while the last two involve fine-tuning, as the network weights need to be modified more slowly. The number of epochs on each step is set to 10. CNN algorithms can demand many epochs used for the backpropagation algorithm to converge on a combination of weights with an acceptable level of accuracy. Especially for RPN training, images patches are extracted from the training data. Here it is important to define the positives examples and negative ones. To avoid overfitting, the created data set is split into training and validation data. 80% of images are used as training data (220 images), and the remaining 20% (50 images), for validation. The split selection is randomized to avoid biasing the results.

Several tests were conducted reducing the number of examples for training and validation.

Figure 3 – The result of recognition of objects by the algorithm

Using the Faster R-CNN Inception v2 model, we were able to train our neural network to recognize objects. After learning the neural network were prescribed a number of conditions to determine the violation. So in appropriate conditions using object recognition, we got good results. Here we will demonstrate the result of the system in case of violations of the on-site parking rules for people with disabilities:

Using the Faster R-CNN model and the OpenCV library functionality, we wrote another algorithm to recognize the violation. our next violation was stopping and parking is prohibited. There is also, a yellow line that prohibits stopping and parking on that side of the road show on Figure 6. Since we already trained the model to recognize objects, we needed to find the yellow line. For this, the HoughLineP function was used, which finds a straight line in the image. as we know the lines in the picture can be expressed in two variables. The HoughLineP uses Polar coordinate systems in which the line is calculated using the formula

$$y = (-\frac{\cos\theta}{\sin\theta})x + (\frac{r}{\sin\theta}) \qquad (2)$$

where r = x cos + y sin. Finding each point *(Xo, Yo)* we can find other lines

$$r\theta = xo \cdot \cos\theta + yo \cdot \sin\theta \qquad (3)$$

where each $(r\theta, \theta)$ shows line *(Xo, Yo)*. For given *(Xo, Yo)* we get a sinusoid using graphics, as an example, $Xo = 8$, $Yo = 6$,

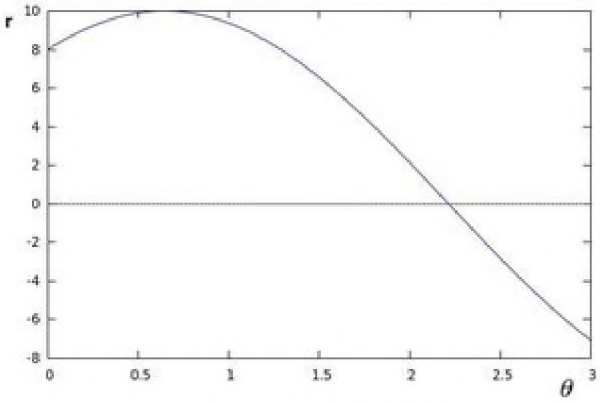

Figure 4 – Graphics of HoughLineP

we take points in a range $r > 0$ and $0 < \theta < 2\pi$. We can do the same operations with all of the points in an image. This is what the HoughLineP does. It keeps track of the intersection between curves of every point in the image. Number of intersections is above some threshold, then it declares it as a line with the parameters $(\theta, r\theta)$ of the intersection point.

However, before we could find the line, we only need to select the yellow line. For this, we took the yellow color on color range and save the mask of the image

Next, using the method of finding the edges by Canny edge detection, we select the contours. After selecting the contours, we use the HoughLinesP function and find the line. The function returns four variables x1, y1, x2, y2, which must be subsequently applied to the image. For this, the standard OpenCV "line" library function was used to draw a line. As a result, we get our yellow line that helps to recognize the violation of parking rules under the signs such as "stop" and "parking is prohibited".

Figure 6 – The result of finding the yellow line

Figure 5 – Mask of image

Next, we find the remaining objects by the type of road and the rest signs and carry out through the violation recognition function.

As a result, we have automatic recognition mechanisms which help to integrate this system in Kazakhstan without big investigations and investments by the pulling population into this system avoiding waste of police resources and time.

The role of society is also important and it cannot be ignored. Potential and resources of people are huge and we should use them. According to statistics taken from the experiment which is well-known as "The Swedish Speed Camera Lottery" which was done in 2010 by Kevin Richardson, shows that people need stimulations to become a law-abiding citizen. Concept of this experiment was taking shots of passing car on a specific road and measure its speed. If the driver crossed the speed limit then fine was sent to the driver. All of the money was used to fill special fund – the lottery prize for obedient drivers. If he was not a violator, he participated in the lottery and had a chance to win money from this fund. As the result of such experiment, 24,857 cars passed the cameras, the average speed limit reduced by itself from 32 km/h to 25 km/h and statistics of car accidents in Sweden decreased significantly [8].

Conclusion

In this article, a sophisticated system of recognition was presented, for effective detection of offence when parking a vehicle under various circumstances. The proposed approach demonstrates several problems solving, punishing pests with less expenditure of resources and educating civil society, and instilling the correct social behaviour of a citizen. In fact, we call for the civil duties of a citizen, by carrot(rewards) and stick(punishment). This procedure helps to raise the importance of laws and rules for citizens, and also brings up a strong civil society, where everyone is responsible for their actions and will not be able to find defects in punishment system for corruption schemes. Using the TensorFlow API and the "Faster R-CNN Inception v2" model pro-

vides enough opportunities to change society, thereby making information technology the most effective and cheap tool for influencing and changing society.

REFERENCES

1. "Connected Consumer Survey 2016: Belarus and Kazakhstan" TNS Infratest (Google Inc.) 2016
2. Zhabaeva, Sholpan "RK Budget Revenues From Paying Advertisements Increase" Informburo.kz, June 16, 2017
3. "Cameras Visibly Reduced the Number of Offenses" Khabar 24, 19 January 2019 News Portal
4. "The project "Sergek" allowed to reduce the crime rate in the capital"Akimat of Nur-Sultan, April 5, 2019
5. Tukusheva, Aigerim "Nearly a Billion Tenge Decline in Sergek Project in Astana" Informburo.kz, July 5, 2018
6. Malyh, Valentine "Application of Convolutional Neural Networks for NLP Tasks" Open Data Science Company / Habr, Habr, 10 Oct. 2018
7. Jorge E. Espinosa, Sergio A. Velastin, John W. Branch "Motorcycle detection and classification in urban Scenarios using a model based on Faster R-CNN" IET Digital Library, 22-24 May 2018
8. "The Swedish Speed Camera Lottery And Healthy Living" The Medical Futurist, 6 July 2018