City Reconstruction Planner with Social Perspective

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***Abstract*—This abstract is about to present online city service management that leverages on our previous work called *post disaster Rebuilding Plan Provider (pd-RPP)*. In that work, we have defined reconstruction plans (for buildings, roads, and other facilities) in accordance with the law and policies by considering available resources, social benefits of affected people, and political priorities of politicians including keeping into consideration the city's structural constraints (like dependencies among units). In the final step, we get different kinds of alternative reconstructions plans and then handed over to decision makers for the selection of the best one to actuate. This research focus on decision-support system for online service management of normal city infrastructure to help municipality and local institution to suggest different alternative plans for managing the public buildings and roads that need maintenance in such a way that the social benefit is maximized. Additionally, the proposed approach is generic and it can be applied to the area of any extension as long as the decision makers share the same goals.**

***Index Terms*—Social Benefits, Recovery, Planning**

I. Introduction

The impact of innovative advancement of science and technologies is growing very rapidly in numerous domains of society [5]. For example, the usage of online services has been a global phenomena in recent years [3]. Because online services not only easy to access, usage wise also really helpful to save time and not much hassle as well. Therefore trend of using online services is getting more popular and people always prefer to adopt this way instead of physical interaction. Due to this government/municipalities also diverging towards e-government online services. e-Government services divided into four phases which are: *presence, interaction, transaction* and *transformation* [1]. *Presence* phase just provides simple information to people on the website to keep them updated about new policies. Because it is the basic right of people to let them know about the new development. The *interaction* phase is about way of communication with the help of email contact and interactive forms it might be between government and citizens (G2C), government to business (G2B), or government agency to government agency (G2G). The third phase *transaction* is about payment of dues and taxes to government, payment for license or payment of using any online service fourth and final phase *transformation* describe how successfully government can be performed and organized things in e-Government system.

Similarly, Technology Assessment (TA) is another methodology that deeply analyzes the impact of technology innovation on society and also suggests useful tips to maximize it's positive impact. There are several kinds of Technology Assessments like traditional TA: is used by experts to give awareness about technological development and its social impacts [9] and new style TA: is used by stakeholders for analysis of technological advancement and its drawback [8].

After all this, we desperately need a new online service that is to be used by the municipality to suggest the people for maintenance/reconstruction of the city's public buildings and other infrastructure which need to repair. Because we can't rely on traditional maintenance strategies. For this purpose, we required an effective management framework on behalf of social benefits of the local community [10]. That needs to handle, from the regional, national and municipal perspective to maintain and repair the buildings and other infrastructure. The maintenance plan covers, but not limited to, the definition of guidelines on how to repair those buildings which need maintenance, figure out what are the most important buildings that need to repair first, and describe all those requirements that must take in place to get back all those to the normality.

Public decision makers always face many issues to define recovery plans like maintaining a balance between involved formal and informal requirements as well as to consider the social benefits of the community [6]. For the aforementioned complexities, the aim of this work is to provide core decision-support system for reconstruction planning and it consider the *Physical* features of the city including *time*, *cost*, *physical dependencies(road/bridges)* and *Social benefits* of the people in accordance with *Political* priorities. The treatment of all these features and the implementation of a solution algorithm that can be accurate and efficient in real situation is very challenging. To handle all these features, we have used a reinforcement learning technique called Double Deep Q-Network (DDQN) for defining different kinds of alternative reconstruction plans to reconstruct damaged infrastructure.

II. Proposed Methodology

We present our proposed methodology for city reconstruction planning of buildings and other infrastructure which consist on three key-steps: *i)* formulation of social based model; *ii)* data extraction and processing to determine the *Enriched Undirected Graph* of that area which needs maintenance by using GisTograph algorithm. This step uses data from Geographic Information System (GIS); *iii)* generation of multiple alternative maintenance/recovery plans by using double deep Q-Network (DDQN) algorithm on behalf of formulated model. Lastly, these generated plans are handed over to the decision makers (politicians + citizens) for the selection of the best plan to actuate. Details of three key-steps are following.

i) Formulation of social based model: We formulate our

problem [6] as an optimization model that determines a plan P by satisfying all the constraints (related to time, budget, and physical dependencies, etc.) and maximizing its social benefits S_P of local people.

Optimization function: which define reconstruction plan P by considering social benefit S_P of local people defined as:

$$S_P = \sum_{v \in P} S(v).(T_e - T_v) \quad (1)$$

ii) GisToGraph: is used for information extraction from GIS data of damage area of city which needs to be transformed into a network structure that incorporates useful information like damage buildings, roads and physical dependencies during reconstruction planning. The resulting network, which we call *Enriched Undirected Graph* (EUG), guarantees the effective manipulation of information in reconstruction phase.

The EUG of the selected area generate in two steps [4]: (i) in the first step collection of required information from that area which needed maintenance (it could be from shapefiles[1] or other city's data repositories); (ii) in the second step transformed input data into the nodes, edges and attributes of the EUG by using (*GisToGraph*) algorithm. Then extracted information's are saved in .CSV and .XLSX files.

For the implementation of GisToGraph algorithm we have used four different classes; *class City, class Street, class Point of interest and class Census Area*.

iii) Reconstruction Planning by DDQN: is used in our proposed approach for defining alternative reconstruction/maintenance plans. In DDQN, convolutional neural networks (CNNs) are used to approximate action-value non-linear functions called Q-function [7]. And it is calculated by *state, action* and *reward* which are defined by following way with respect to our approach:

State: is a tuple which is consisted of *(current location, remaining budget, remaining time)*.

Action: is the possible agent moves in the available action space, which is composed by *reconstruction units ID*.

Reward: is the social benefit calculated by the immediate reward function.

During the implementation of DDQN we have used following influential hyper parameters Table I.

TABLE I
FIXED PARAMETERS

Fixed Parameters	**Value**
Optimizer	Adam optimizer, learning rate = 0.001
Loss function	Mean squared error
Q-Learning function	Q(s,a;θ) = $S_r(v)+\gamma \max_{a' \in A_v} Q'(s', a'; \theta_i^-)$
Batch size	32
Steps before training	15000
Maximum memory size	2000
Political Priority	Minimum=0 , Maximum =10
Exploration strategy	Epsilon greedy policy (Epsilon $\in 10^{-7}, 1$ and self.epsilon_ decay=0.0003.)
Reward discount factor	self.discount_factor = 0.95
Input Parameters	'Budget' and 'Time' (T_e)

[1]http://opendata.regione.abruzzo.it/catalog

III. CONCLUSION

In this work, we have proposed online service management decision-support system by using a double deep Q-Learning network (DDQN) for reconstruction/maintenance of damaged infrastructure. Our approach is consisted on key features of reconstruction planning like *time* and *cost* required for reconstruction including *physical dependencies, social benefits* of affected community and *political priority* to consider politicians' input. In the end, we get different kinds of alternative reconstruction plans by satisfying all the constraints on behalf of social benefits. We have successfully validated our approach on "Sulmona" data. As a future work: **Performance Comparison:** Our research problem contain dynamic action space [2], [6], for this purpose to check the performance of DDQN will make comparison with Q-Learning, SARSA, Deep SARSA, and Policy gradient algorithm by considering all key attributes like *time, cost, number of people, damage level of buildings, physical dependencies, political priorities* and *constraints*.

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