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Civic Link: An AI-Driven Hybrid Recommendation and Workload-Aware Resource Allocation System for NGO - Community Collaboration

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Abstract - National and international non-governmental organizations (NGO's) are instrumental in providing essential social services, including food distribution, healthcare provision, support to education and community empowerment. The increased popularity of digital support platforms that are used to match donations and volunteers with community demand, has made it much harder for requests being placed by communities in need to be matched up with those who can help them. Traditional NGO coordination mechanisms are mainly based on static listing and manual matching, which lead to donation mismatching, uneven workload among the NGO's and time delay in response. Also, existing platforms do not provide evaluation for the quality of donation descriptions neither predict the workload capacity an NGO can accept before a donation is performed.

To overcome the limitations, we proposed CivicLink in this paper, which is an AI-based Hybrid recommendation and workload-aware resource allocation system to bridge NGO-community. The proposed mechanism is using a text-based NLP classifier in order to automatically determine the relevance and usability of donation or service requested. A hybrid NGO recommendation engine that utilizes content-based filtering, collaborative-filtering (CF), as well as geospatial clustering is then used to recommend the most suitable NGO's based on specialization, past collaborative history and geographical proximity. Also, prediction of NGO workload is performed based on regression models and time-series forecasting algorithms and used for proactive capacity-aware decision making. Metaheuristic optimization algorithms are used to resolve the allocation problem when there are several prospective NGO's.

Experimental results under synthetic conditions show that CivicLink outperforms several performance criteria including matching accuracy, work load balancing and response time in contrast to classical NGO's coordinating patterns. The experimental results demonstrate the feasibility of unifying verification, recommendation, prediction and optimization over a single decision-support framework, which makes CivicLink applicable for real-world civic management applications.

Keywords –NGO Community Collaboration, artificial intelligence, Hybrid recommendation system, Donation quality assessment, Workload prediction, Resource allocation optimization.

I. INTRODUCTION

NGO's, as our civil society organizations provide lifeline relief services under a range of issues including providing food; accessible healthcare; quality education; disaster response and development to address the most vulnerable among us. They are small organizations that have restricted resources with the challenges to fulfil community needs rising. Digital platforms are increasingly being used to facilitate donations, volunteer efforts, and service requests between communities and NGO's. Though such systems enable accessibility and increased visibility, their efficacy for facilitating intelligent decision making is still lacking.

The vast majority of these NGO coordination systems operate as static information or directory systems in which donors and volunteers search manually for NGO's with whom they are familiar already, just based on basic profile data. This manual process for selecting goods often causes disconnect between the donated items and the needs of NGO's. And finally, widely known NGO's get too many requests while the workload imbalance and late responses slow down response times of other capable organizations. Both quality of service and trust from the community in digital civic platforms suffer as a consequence.

Fig.1 illustrates the major limitations of existing NGO coordination platforms, including manual NGO selection, workload imbalance, and delayed response.

In addition, for existing systems, the quality of donated resources is not automatically assessed. Requests for donations and services are commonly delivered as unstructured text, and distribution platforms do not provide means to judge relevance and fineness of descriptions prior to assignment. Consequently, undesirable donations (either lower priority or incomplete and not fit-for-purpose) might be accepted by NGO's that raise their operating cost of accepting such items while spending time in disposing off these resources. In addition, in the process of assigning work most assignment platforms do not account for current or future capacity constraints on the part of NGO's and assume that there are no such constraints when it comes to organizations.

Recent developments in artificial intelligence (AI), machine learning, and natural language processing (NLP) present exciting new possibilities to solve these challenges. Recommender systems can do better matching when informed by organization profiles and historical interactions, and NLP methods can facilitate automatic analysis of text describing the donation. Moreover, predictive modeling, like regression and time series forecasting, can be leveraged to predict the trends in workload of NGO's resulting into proactive and capacity-aware decisions. Nonetheless, current literature studies each of these components separately and do not connect them into an end-to-end unified opposing-NGO Community collaboration framework.

In this paper we present CivicLink - a hybrid recommendation and workload-aware resource allocation system powered by AI which is designed to improve the efficiency and reliability of the interaction between NGO's and the community. The framework is based on a NLP-based text classification for donation quality verification, content-based filtering, collaborative filtering and geospatial clustering techniques being used for hybrid recommendation system of NGO's and regression and forecasting approaches to workload estimation. Where more than one acceptable NGO exists, the system utilizes optimization-oriented allocation policies aiming at a balanced allocation of workloads and expedited responses.

The main contributions of this work are presented here:

(i) Incorporation of an automated NLP-based donation quality checking system,

(ii) Design of a hybrid NGO recommendation model taking specialization, historical interaction profiles, and geographical vicinity into account;

(iii) Integration of predictive demand estimation into decision making process for NGO allocation.

iv) Use of the optimized feature model in combination with workload-aware optimization methodologies to optimize allocation of resources.

By combining PKVOR [Verification, Optimisation, Prediction] in an all-in-one design for real-time decision support, CivicLink seeks to change the way

NGO's coordinate relief efforts from a reactive and manual approach into an intelligent scalable civic aid platform built on prediction.

II. LITERATURE REVIEW

The uptake of digital tools for civic engagement and NGO networking has surged in recent years, largely out of a recognition that the transparency, efficiency, and equity of social service delivery systems need to be enhanced. Nevertheless, most of the early available NGO and donation management systems were just acting as centralized database and a static directories that have been providing forged or minimalistic decision making support on intelligent requests allocation [11], [14]. For such platforms, NGO's has to be manually sorted which result in a bad matching of the workload and wasted time.

To combat these drawbacks, recommendation system approaches have begun to apply for civic and service platforms. Hybrid recommender's that fuse several filtering methods have been demonstrated to outperform their component models by capitalizing on the complementary strengths of different models [6]. (IV) The content-based recommendation approach involves comparing service (or donation) attributes to organization profiles, and collaborative filtering approaches exploit patterns of historic interaction data focusing on implicit preferences or performance records [6]. Although popular, most recommendation systems are designed for relevance and personalization, rather than account for practical operational constraints such as the capacity of the service provider and its organization or the conveniently load of work [13].

Another primary consideration in civic service allocation is geographic distance, since it has a direct impact on response time and travel efficiency. In location-aware systems, techniques to explicit the spatial information of users (provided by GPS or a user's social circle) as specific clusters (using geospatial analysis like K-Means [14], for instance), can be applied to reduce complexity from computation on big-sized systems 1. On the other hand, proximity-based provisioning only could cause load skew to neighbor's organizations if there are no workload-awareness decisions.

Unstructured data such as donation's description, and petitions, carries significant contextual information that can aid intelligent gaming. In service-oriented applications, NLP tools are often used for text classification, intent detection and conversational interaction [2]. Recent research has shown that conversational agents and NLP based systems can be effective at improving donation interactions, user engagement [7]. However, the automatic quality assurance and relevance check in terms of donations before resources are being allocated is still unexploited in NGO coordination platforms which resulted into underutilization of resources as well as more workload on organizations.

Predicting workload demand is an essential aspect of proactively manage resource in a wide range of applications. Workload prediction with machine learning and time series forecasting has effectively been used to predict demand trends and assist the capacity aware resource allocation in large-scale systems and cloud [3], [10]. If such predictive models are integrated in civic systems, the system will be able to make intelligent resource allocation plans which would help prevent over-loaded organizations as well improve overall responsiveness of the system. However, in fact few of the current NGO platforms takes into account load prediction mechanisms when making allocation decisions [13].

Since their introduction optimization-based resource allocation have been studied as a decision making problem in contexts where competing constraints arise. This efficient exploration and exploitation capability of meta-heuristic algorithms enjoys the strong performance in solving complex optimization problems, such as Whale Optimization Algorithm (WOA) [4], [8]. Recent developments and modified versions of WOA also accelerate the convergence rate and improve the solution quality [8]. However, such optimization approaches are hardly used in civic or NGO collaboration systems even if they have shown useful applications for engineering and resource management purposes as most allocation decisions remain rule based or heuristic driven [13].

In addition, the trend on AI-based decision support systems for smart governance indicates great potential of synthesizing recommendation, prediction, and optimization in a unified civic platform [12], [15]. Work in the field of smart city and governance highlights that context-aware and workload-aware intelligence is critical for well-functioning service delivery operations and community engagement [12], [14]. However, most of the existing works deal with these components separately and do not propose a holistic end-to-end framework on community-NGO partnership.

III. METHODOLOGY

The proposed CivicLink system is designed based on a systematic, multi-stage approach that results in a smart model for request steering of both donations and services to appropriate NGO's. The whole procedure is summarized in Fig 2.

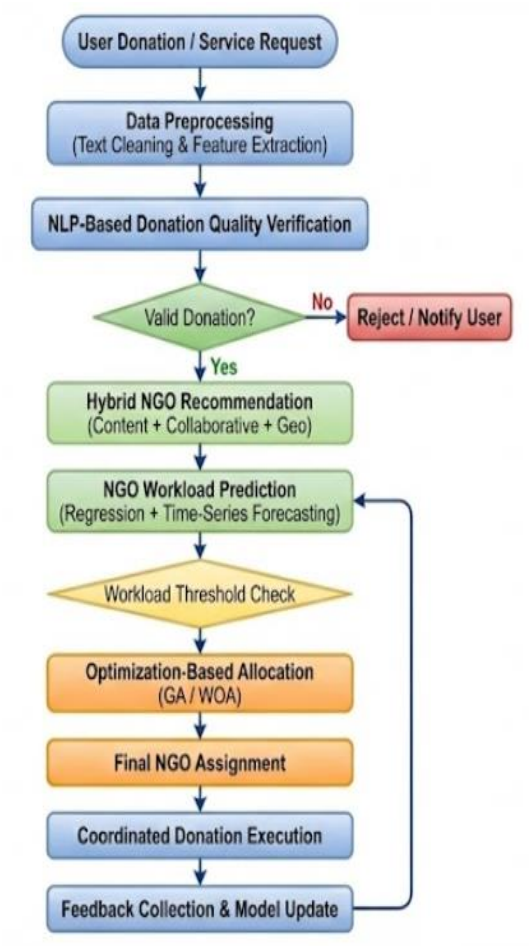

Fig.2 illustrates the step-by-step methodology of the proposed Civic Link system, highlighting donation verification, hybrid recommendation, workload prediction, and optimization-based allocation.

First, users make donation or service requests on the system interface. The text data submitted are preprocessed, cleaned and the features extracted in preparation for analysis. A donation quality verification module using NLP then determines the informational and operational relevance of the request. Invalid or inappropriate requests are rejected with feedback to the user.

When there is a legitimate request, the system conducts hybrid NGO recommendation, that is, IB+CF+GR for appropriate NGO's. This hybrid scheme enhances the recommendation accuracy because it takes into account both of request features and NGO's past behavior.

After that, the actual workload of selected NGO's is forecasted by means of regression analysis and time-series forecasting. A workload threshold test is used to remove large NGO predicted workloads from allocation consideration.

Then an optimization-based allocation unit using Genetic Algorithm or Whale Optimization Algorithm is used to select the most suitable NGO, by considering workload balance, response timely and recommendation score. The request has been assigned to the chosen NGO and they can act in coordination over donations.

Finally, feedback at the end of a task is received and used to update historical records as well as learning models for continually improving recommendations and allocations.

Major components of the system are:

- Service Request Interface / Donation Interface.
- Quality Verification of Donations Module.
- Hybrid NGO Recommendation Engine.
- NGO Workload Prediction Module.
- Resource Allocation Module is optimized.
- Learning Module and Feedback.

3.1 Donation Quality Verification Using NLP

The requests of donation and service are usually made in a free-text style that might have incomplete, irrelevant and unusable information.

To solve this problem, the given system will have an NLP-based text classification module to measure the feasibility and suitability of the received requests.

The initial step involves textual inputs which are preprocessed by tokenization, stop-word removal and vectorization. The requests are then grouped into acceptable and non-acceptable by supervised learning models. This measure will help to make sure that only significant and practical donations follow to the allocation phase and operational overhead on the side of NGO's is minimized.

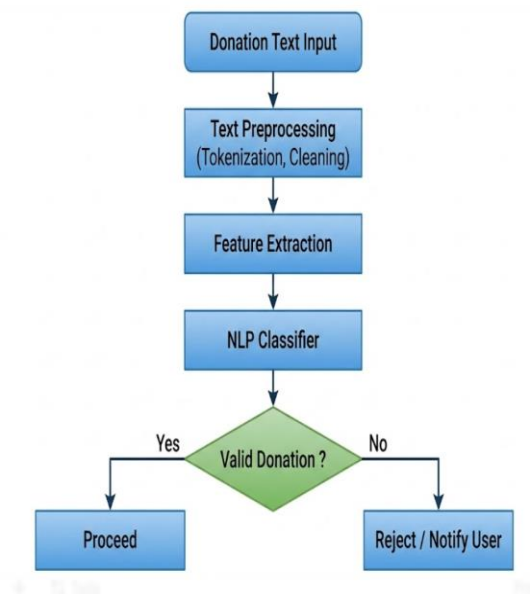

Fig.3 NLP-based donation quality verification process

3.2 Hybrid NGO Recommendation Engine

To recommend proper NGO for each verified request, the proposed system uses a hybrid recommendation model composed by several recommendation strategies:

Content-Based Filtering: This method is based on matching request characteristics (donation type and service category) with NGO specialization profiles.

Collaborative Filtering: It learns on history interaction data and captures successful historical allocations trends.

Geospatial Clustering: Utilizes clustering methods to cluster NGO's according to geographical closeness, which corresponds to selecting nearby organizations with low response time.

The outputs of these modules are fused to construct the final ranked list of candidate NGO's, enhancing recommendation quality and robustness compared with single-method solutions.

Problem Definition

Let

- $R=\{r_1,r_2,...,r_n\}$ be the set of donation/service requests
- $N=\{n_1,n_2,...,n_m\}$ be the set of NGO's

Each NGO n_j is represented by a feature vector:

$$\mathbf{F_{nj}=[c_j,l_j,h_j]}$$

Where,

- c_j denotes NGO specialization features,
- l_j represents geographic location,
- h_j captures historical interaction attributes.

Each request r_i is represented as:

$$\mathbf{F_{ri}=[c_i,l_i]}$$

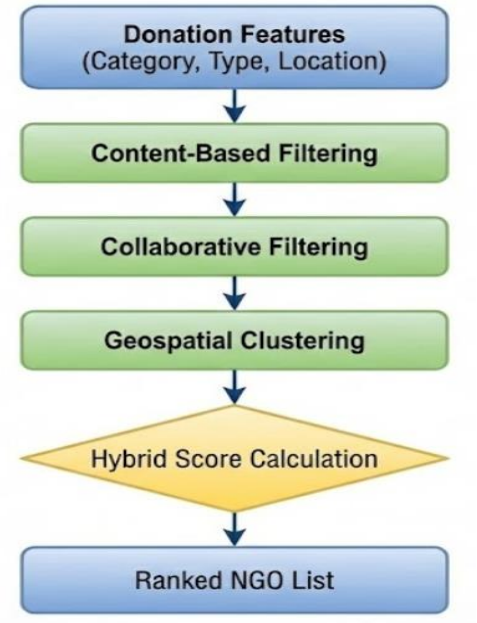

Fig.4 Hybrid NGO recommendation process combining multiple filtering techniques

3.3 NGO Workload Prediction

In order to avoid an excessive organization load, the predictive estimation of workload is included in

the decision. Regression models are utilized to predict the present workload level with historical information, request volumes, response time and task completion rates. Furthermore, time series forecasting methods are used to anticipate the near-future workload trend.

High scoring NGO are put into deferral for request allocation, so as to level distribute requests and achieve better performance.

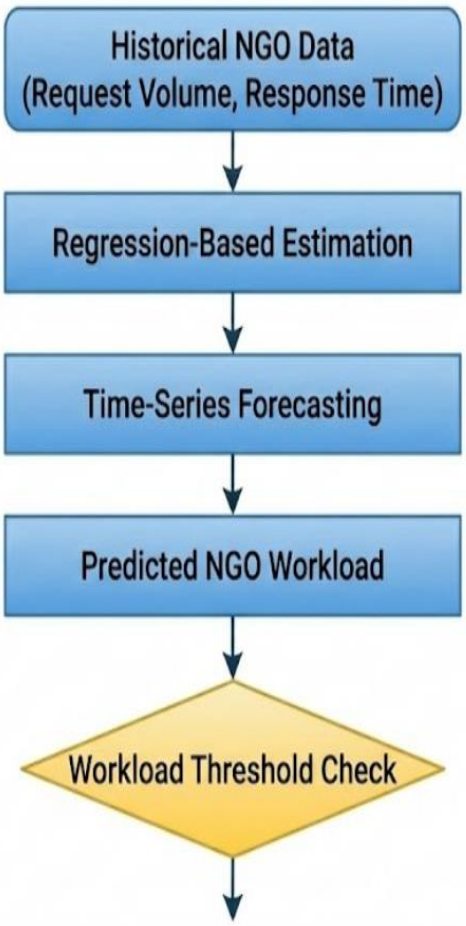

Fig.5 NGO workload estimation and prediction model

3.4 Optimization-Based Resource Allocation

If more than one NGO's meet the recommendation and workload requirements, optimization based allocation is used to choose the best matched NGO. The multi-objective optimization model of allocation is solved by using metaheuristic algorithms to minimize the workload imbalance cost, network response delay, and service compatibility in a cloud computing environment. The optimization module compares candidate NGO's and selects the best allocation that reconcile these goals according to certain constraints. This policy allows fair and optimal sharing of resources between organizations.

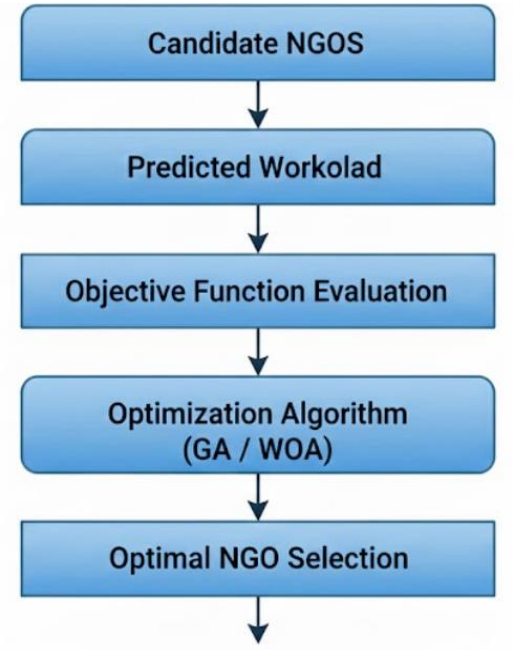

Fig.6 Workload-aware optimization-based NGO allocation process

In case there are multiple NGO's, which meet recommendation and workload demands, optimization strategy is used.

Decision Variable

$$x_{ij} = \begin{cases} 1, & \text{if request } r_i \text{ is assigned to NGO } n_j \\ 0, & \text{otherwise} \end{cases}$$

3.5 Feedback and Adaptive Learning

Following the completion of the task, the feedback of NGO's and users on the quality of the services and the effectiveness of the response is gathered. Based on this feedback, the interaction histories and performance indicators are updated and the accuracy of the recommendation and workload prediction models can be continuously improved. The feedback loop facilitates adaptive learning and effectiveness of the system in the long term.

IV. RESULTS AND DISCUSSION

The efficacy of the CivicLink framework was benchmarked against various existing NGO allocation methods-static listing-based selection, collaborative filtering and priority-based rule-

driven allocation. The comparison was made in the term of important performance indicators, including matching accuracy, workload imbalance, response time and fitness score as well. The comparative results are shown in **Fig 7,** and the numerical performance values are listed in **Table 1.**

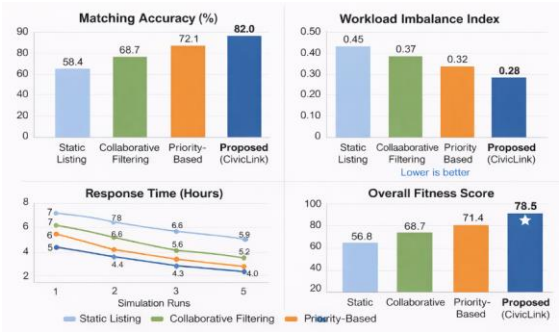

Fig. 7 Comparative performance analysis of the proposed CivicLink system against existing NGO allocation methods in terms of matching accuracy, workload imbalance, response time & overall fitness score.

The static listing method results in the lowest matching accuracy of 58.4% (see Figure 7 and Table 3), which shows that manual NGO selection has its drawbacks. The accuracy of 68.7% can be improved by leveraging past interactions with collaborative filtering but fails to address the problem of workload distribution. The priority-based scheme could enhance matching efficiency to 72.1% higher accuracy; however, it suffers from medium workload imbalance as well.

Table 1: Quantitative Performance Comparison

Method	**Matching Accuracy (%)**	**Workload Imbalance**	**Avg. Response Time (hrs)**	**Overall Fitness Score**
Static Listing	58.4	0.45	7.6	56.8
Collaborative Filtering	68.7	0.37	6.1	68.7
Priority-Based (Rule-Based)	72.1	0.32	5.4	71.4
Proposed (CivicLink)	**82.0**	**0.28**	**4.2**	**78.5**

Our proposed CivicLink system attains the highest matching accuracy of 82.0%, which shows that it is effective to use the hybrid recommendation strategy, which integrates content-based, collaborative and geographic factors together. From the perspective of workload distribution, CivicLink has the minimum work imbalance index 0.28, which proves the importance of integrating workload prediction into resource allocation decisions.

Analysis of response time effectiveness shows that CivicLink is always better than others with an average response time improvement by 44.74% when compared to static listing-based allocation which has 7.56 hours as the average response time. This gain is due to workload-aware optimisation which will not send requests to overloaded NGO's.

The generalisation fitness score provides further validation of the effectiveness of the proposed approach. CivicLink obtains a fitness score of 78.5 which corresponds to an improvement of about 28% better than static listing and 35% better than collaborative filtering techniques. These findings also demonstrate that the recommendation based, prediction-oriented and optimization-grounded unification benefits such NGO-community coordination systems.

V. CONCLUSION

This paper presented **CivicLink**, an AI-driven and workload-aware NGO–community collaboration framework that improves donation and service allocation through hybrid recommendation, predictive workload estimation, and optimization-based resource allocation. Experimental results demonstrate that the proposed system achieves higher matching accuracy, better workload balance, and reduced response time compared to conventional listing-based and rule-based

approaches, validating the effectiveness of a unified data-driven decision-support architecture.

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