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Hybrid ANN-CBR model for disputed change orders in construction projects

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Abstract

The purpose of this paper is to provide a method that can be used to solve potential lawsuit problems caused by change orders in construction projects. A hybrid Artificial Intelligence (AI) model, the Hybrid ANN-CBR Model (HACM), is developed utilizing the AI branches of Artificial Neural Networks (ANN) and Case Based Reasoning (CBR). The research is based on the litigation archives collected by the Supreme Courts and appellate courts in 48 states and one district of the USA. The accuracy of the HACM prediction rate reaches 84.61%, not only for predicting litigation likelihood by using the ANN approach but also utilizing the CBR approach to yield warnings and display litigation information related to past cases. After evaluating 31 cases it is confirmed that the model HACM performs well especially for those medium sized construction projects. It can be concluded that it is feasible to link ANN and CBR together to provide a tool with a relatively high rate of prediction accuracy and a conceptual model to solve potential severe disputes cased by change orders.

Keywords: Construction management; Litigation; Disputes; Change orders; AI; ANN; CBR

1. Introduction

Unplanned for changes in construction projects can cause additional work beyond that expected, resulting in extra cost and time [1]. Since contract recognition by two parties is diverse, communication between the parties is likely to be harmful even though owners and contractors may gradually realize that the project changes are reasonable. In other words the changes may raise disputes between owners, contractors and subcontractors. In general, the common methods of dealing with construction disputes are by prevention, negotiation, mediation, arbitration and litigation. Among these resolutions there are not many studies discussing construction litigation from the viewpoint of prevention. Using litigation as the ultimate dispute resolution is the last alternative for construction disputes even though litigation has legal force because it often causes the expenditure of a huge amount of cost and time. Litigation cases, however, raised by project changes continue to exist, and the data show that change orders comprise one of the major causes of litigation [2].

Both owners and contractors hope to avoid the litigation solution, thus if a system is designed which provides early warning this would be useful. In this research we develop a hybrid model named the ANN-CBR Model (HACM), which utilizes the Artificial Neural Network (ANN) and Case Based Reasoning (CBR) approaches to meet the goal. The model possesses the learning feature of the ANN approach and the similarity calculating feature of the CBR approach. The purposes are to warn an ongoing project that faces potential litigation caused by disputed changes, and to provide information related to stored cases suggesting procedures for settling disputes caused by change orders.

2. Dispute management

Disputes are definitely not welcome in any construction project. Many studies have sought methods to avoid and resolve disputes before litigation occurs. Muller presents Alternative Dispute Resolutions (ADR) for the construction industry [3]. Spittler and Jentzen provide a description of construction dispute resolution by managing conflict with step-by-step negotiations [4]. Bishop proposes a method of planning for disputes by educating construction management [5]. Zack presents a study of practical dispute management [6]. Brown introduces a method of managing a legal team through dispute resolution [7]. Jahren and Dammeier conduct an investigation into construction disputes [8]. AbouRizk and Dozzi develop a computer simulation application for

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Table 1
Format for investigating litigation archives [2]

Project data	
What is the project type?	Residential, commercial, industrial, institutional, infrastructure, military, waste disposal or maintenance
What type of construction was this project?	Addition/expansion, new, renovation
What is the project size in dollars?	$_____
The owner was a private or public?	Private or public
For this litigation, plaintiff vs. defendant was:	Gen. vs. Sub. Contractor, CM vs. Gen. Contractor, or Owner vs. Gen. Contractor
Contract type for this project?	Lump sum, cost+fee (% or fixed, guaranteed max), unit price, verbal estimate, etc.
Estimated project duration at contract award?	_____ calendar weeks
Actual project duration at completion if finished?	_____ calendar weeks
Was there a fixed end date?	Yes or No
Was a schedule extension asked for?	Yes or No
Was a schedule extension granted? Why needed?	Yes or No
Disputed issue data	
Disputes raised due to what reasons?	Finance, performance, payments, contract, changes, etc.
What was the most dispute happening in the project?	Cost, schedule, or both
Did changes occur in the project?	Yes or No
Did the contract request written change orders	Yes or No
Was there any arbitration decided before the litigation?	Yes or No
Did disputes result in partial or total work stoppage?	Yes or No
Number of Owner initiated changes:	_____
Number of Contractor initiated changes:	_____
Number of changes submitted:	_____
Number of changes approved:	_____
How many changes caused disputes?	_____
Additional compensation approved:	$_____
Additional compensation argued:	$_____
Possible reasons for changes indicating % of actual executed man-hours of change orders.	Additions, change in code, change in tech., deletions, design change, etc.

resolving construction disputes [9]. Steen gives five steps to resolving construction disputes without litigation [10]. Cheung, Tam, and Harris research Project Dispute Resolution Satisfaction (PDRS) classification through neural networks [11]. Chau discusses the Hong Kong experience of resolving construction disputes by mediation [12]. Mitropoulos and Howell offer a model for understanding, preventing and resolving project disputes [13]. The afore-mentioned literature is all related to how to resolve or prevent construction disputes, but provides no advice for potential litigation in projects when serious disputes occur.

In the literature related to construction litigation, not many studies discussing and categorizing the characteristics of prosecuted project litigation exist. Sweet discusses the legal aspects of architecture, engineering and the construction process [14]. Shin identifies critical dispute characteristics of construction project operations using legal construction cases [15]. Arditi and Tokdemir use the ANN and CBR approaches respectively to predict the outcomes of disputed construction project litigation in Illinois. Their CBR prediction rate is 83% and the ANN is 67% [16,17]. Although in these 15 studies the legal and compartmentalized features of construction litigation are discussed, the concept of early warning by the integration of AI or other approaches has not been often applied.

3. Artificial neural networks

The ANN approach is an information processing technology based on simulating the human brain and nervous system. It is usually applied to establish forecast models [17]. Among the algorithms fitting the approach, the Back-propagation (BP) algorithm serves as the most representative and practical [26,27], being an efficient approach for training multiple-layer artificial networks derived from the supervised learning concept. The input layer receives inputs in relation to question-inquiring from the outside. The hidden layer(s) calculate interactions among the neurons where the optimal numbers of neurons and layers are configured as a result of trial-and-error. The output layer produces the outcomes that are the solution of the initial question-inquiring.

Table 2
Investigated and accepted archive numbers [2]

State name	Accepted/investigated	State name	Accepted/investigated	State name	Accepted/investigated	State name	Accepted/investigated
AL	2/65	IA	1/45	NV	0/16	SD	3/39
AZ	3/51	KS	5/169	NH	3/14	TN	23/106
AR	3/60	KY	1/58	NJ	5/65	TX	17/271
CA	15/406	LA	34/241	NM	0/47	UT	6/50
CO	2/46	ME	3/32	NY	12/341	VT	1/16
CT	29/200	MD	4/64	NC	7/89	VA	4/68
DC	2/43	MA	3/111	ND	3/37	WA	6/125
DE	5/54	MI	3/57	OH	32/285	WV	3/32
FL	0/185	MN	10/86	OK	4/123	WI	17/111
GA	2/92	MS	3/49	OR	1/51	WY	5/27
ID	0/37	MO	18/165	PA	9/155	Total	340/4818
IL	16/217	MT	0/32	RI	5/29		
IN	3/64	NE	5/46	SC	2/46		