

# A hybrid evaluation of information entropy meta-heuristic model and unascertained measurement theory for tennis motion tracking

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**Abstract.** In this research, the physical education training quality was investigated using the entropy model to compute variance associated with a random value (a strong tool). The entropy and undefined estimation principles are used to extract the greatest entropy of information dependent on the index system. In the study of tennis motion tracking from a dynamic viewpoint, such stages are utilized to improve the perception of the players' achievement (Lv *et al.* 2020). Six female tennis players served on the right side (50 cm from the T point). The initial flat serve from T point was the movement under consideration, and the entropy was utilized to weigh all indications. As a result, a multi-index measurement vector is stabilized, followed by the confidence level to determine the structural plane establishment range. As a result, the use of the unascertained measuring technique of information entropy showed an excellent approach to assessing athlete performance more accurately than traditional ways, enabling coaches and athletes to enhance their movements successfully.

**Keywords:** hybrid evaluation; information entropy; tennis motion tracking; unascertained measurement theory

## 1. Introduction

Like any other sports, tennis as a commonly played sport faces some advances in materials that greatly affect the advancement of techniques and racket design methods, which highly affect the types and injuries 'ratio in players (Abedini *et al.* 2020, Guo *et al.* 2021, He *et al.* 2021b, Huo *et al.* 2021, Shao *et al.* 2021, Zhang *et al.* 2021a). The introduction of high-speed computers and high-resolution/frame rate cameras has enhanced study interest for applications such as defense, military, and sports in computer vision algorithms (Assfalg *et al.* 2002, Zuo *et al.* 2013, Huang *et al.* 2021b, Peng *et al.* 2021, Sun *et al.* 2021, Wu and Habibi 2021). One of the most commonly performed tasks within these applications is evaluating the number, location, and movement of different objects (Shariati *et al.* 2011a, 2019a, Sinaei *et al.* 2011, Shahabi *et al.* 2016, Khorramian *et al.* 2017). For aims such as tactical analysis in various sports, including tennis (Sudhir *et al.* 1998), football, baseball (Han *et al.* 2002), and soccer (Assfalg *et al.* 2002), the motion analysis and tracking information given by computer vision techniques may be applied (Grimson *et al.* 1998, Arabnejad Khanouki *et al.* 2010, Mojtaba 2011, Sinaei *et al.* 2012, Shariati *et al.* 2020f, Davoodnabi *et al.* 2021). Motion data also offers a clearer interpretation of the game for the settlement of controversial referee decisions. Examples include the QUESTEC (Legg 2003) automated line-call system, the Hawk-Eye (Reid *et al.* 2016) system that lets the commentary team interpret the game, and the automatic off-

side detection system (Lam *et al.* 2003, Bai *et al.* 2020, Yue *et al.* 2020, Hou *et al.* 2021). An active area of study is identifying and tracking objects during a sports event. Effective attempts have been made, as a soccer ball tracking system (He *et al.* 2018, D'Orazio *et al.* 2002) on the basis of a tweaked Hough transforming method, and a baseball tracking system applying technologies for color-based area detection (Theobalt *et al.* 2004, Shariati 2008, 2011b, Hamidian *et al.* 2011, Toghroli *et al.* 2018, 2020, Dai *et al.* 2021b, Liu *et al.* 2021d). Whilst, in real-world tennis implementations, there are not many examples of successful deployment of such devices. In a tennis game, tracking the ball faces multiple problems due to the limited size and high pace of the ball (Pingali *et al.* 2000, Huang *et al.* 2021a, Zhang *et al.* 2021b, c). Tracking the tennis ball allows for simulated replays, new game statistics, and other visualizations that contribute to new ways to view and interpret tennis matches. Several other uses will also benefit from real-time tracking of the tennis ball, including computer-assisted refereeing and player preparation (Zhang *et al.* 2019, Dai *et al.* 2021a, Ghabussi *et al.* 2021, Liu *et al.* 2021c, Najaafi *et al.* 2021). Owing to the small size of the ball, the comparatively large size of the court, the high speeds at which it moves, changing lighting conditions, and variable contrast between the ball and the background around the scene, it is difficult to follow the tennis ball. For this use, the identification and tracking algorithms focused on Object-based and non-objects, such as the circular Hough transform (Barron *et al.* 1992, Bennett *et al.* 1999, D'Orazio *et al.* 2002, Li *et al.* 2020b). The objects that these devices operate with typically move much slower than the tennis ball. Moreover, images of fast-moving objects are typically distorted, which makes it more difficult to distinguish (Intille *et al.* 1997, Ishii and Ishikawa 1999,

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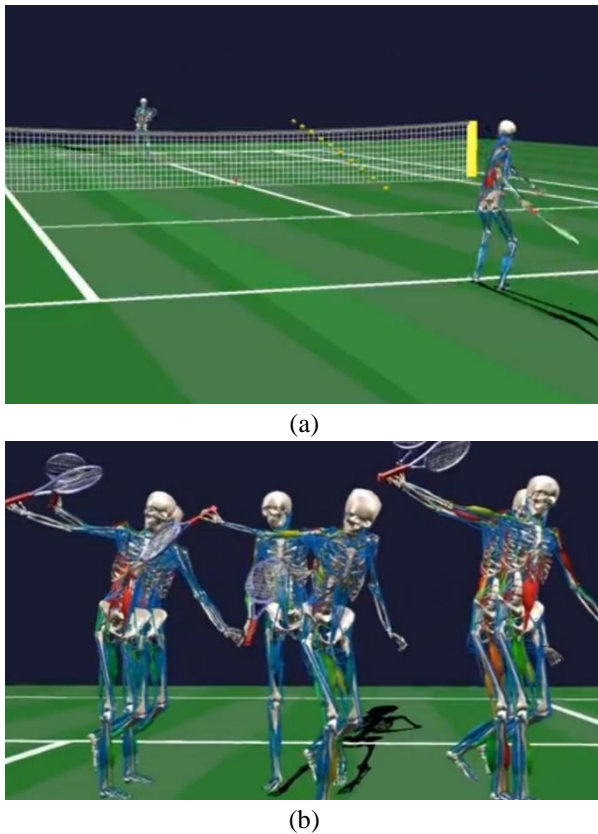


Fig. 1 The simulation of tennis motions (a) Forehand drop, (b) Back hand drop

Alipour *et al.* 2020, Kordestani *et al.* 2020, Liu *et al.* 2020d, Wang *et al.* 2020e). They track objects that are far larger than a tennis ball (Jiang *et al.* 2018). In comparison, there are poor resolutions and frame rates for most cameras used by these techniques (Toghroli *et al.* 2017, Li *et al.* 2019a, Shariati *et al.* 2019b, Hosseini and Toghroli 2021, Mehrabi *et al.* 2021). The rapid speed of processing obtained by these techniques relies on the limited size and number of photographs. In order to get a clearer view of the tennis ball, if high resolution/frame rate cameras are chosen, their processing speed would be heavily affected. In real-world applications, only a few successful implementations of tennis ball tracking systems (Gwasda *et al.* 2000, Bradski 1998) as Sudhir *et al.* (1998) and Pingali *et al.* (2000) have recently been published. However, in a real-world context, they did not have systematic analysis of performance and errors (Shariati *et al.* 2011b, 2019e, Shi *et al.* 2017, Ziaei-Nia *et al.* 2018, Trung *et al.* 2019, Abedini and Zhang 2020, Afshar *et al.* 2020). In addition, these approaches have not addressed player-ball contact and occlusion of the ball because of players. In the last two decades, a significant number of object detection and tracking methods have been improved (Liu *et al.* 2016, Kordestani and Zhang 2020, Liu *et al.* 2020c, Shi *et al.* 2020). They could be loosely divided into two classes: based on objects and based on non-objects. Object-based methods are ideal for identifying and tracking objects in the video frames that are distinct from others, i.e., the target objects can quickly be identified (Nosrati *et al.* 2018, Yang *et al.* 2018, Milovancevic *et al.* 2019, Sajedi

and Shariati 2019). Most of these approaches require the development of a model showing the target object, the extraction of properties of objects, and the discrimination of target objects. If the properties applied for object identification and tracking are not from the object itself, it is possible to employ non-object-based approaches (Ni *et al.* 2019a, Cheshmeh *et al.* 2020, Moayedi *et al.* 2020b, Shariati *et al.* 2020b, 2021a). It is possible to further classify object-based methods into three groups: model-based, feature-based, and motion-based (Zhang *et al.* 2010, Moayedi *et al.* 2020a, Oyarhossein *et al.* 2020). The object attribute states as color and shape are applied in feature-based algorithms to distinguish target objects in a frame from others (Habibi *et al.* 2018, Ebrahimi *et al.* 2019, Hashemi *et al.* 2019, He *et al.* 2020, Liu *et al.* 2020b, Zhou *et al.* 2020). In order to discriminate against moving objects, motion-based models evaluate the sequence(s) of video frames, collect and interpret the motion constancies over frames (Fazaeli *et al.* 2016, Ghazanfari *et al.* 2016, Hosseini *et al.* 2018, Xu *et al.* 2018). The identification and tracking is considered an undistinguishable object problem if there is practically no property available to differentiate the target objects from others (Lucas and Kanade 1981, Mohammadhassani *et al.* 2013b, Habibi *et al.* 2016, Heydari and Shariati 2018, Shariati *et al.* 2020a, Wang *et al.* 2020d, Ma *et al.* 2021).

A variety of non-object-oriented models were built to solve the problem. This method could not determine whether the target object is a single object, in contrast, it considers certain other features, such as background information that involves location, time, movement of people, and surrounding environment information. To detect objects, model applies high-level semantic and domain awareness (Lam *et al.* 2003, Ma *et al.* 2020, Huang *et al.* 2021c, Zhao *et al.* 2021). Object detection and tracking are conducted on the basis of these generated models. Centered on an entity model that systematically explains the tennis ball, we can also detect the tennis ball using this idea (Eaton and Scassellati 2000, Liu and Liu 2020, Jiao *et al.* 2021, Liu *et al.* 2021f, Xu *et al.* 2021). However, because the same object will behave very differently under different circumstances, a single model couldn't adequately represent the underlying objects (Toghroli *et al.* 2014, Safa *et al.* 2016, Sedghi *et al.* 2018, Katebi *et al.* 2019, Shariati *et al.* 2020d, Yu *et al.* 2022). The appearance of the tennis ball, for instance, varies under various lighting conditions, intensity, and size. We may construct a variety of models that, under all practicable situations, thoroughly represent the tennis ball. Motion based algorithms detect an object from a series of images based on the motion information extracted. This style of methodology does not actually demand that the object models be constructed directly (Liu *et al.* 2020a, Xu *et al.* 2020, Zhu 2019). The movement data seen during a tennis event is very clear (Mi *et al.* 2020). Following spatial patterns, the ball continuously travels around the ground (Das and Anand 1995, Ishikawa 1998, Han *et al.* 2002, Xu *et al.* 2003). We are able to increase the precision of identification if the motion knowledge of the tennis ball can be obtained. However, it is not necessary to merely follow

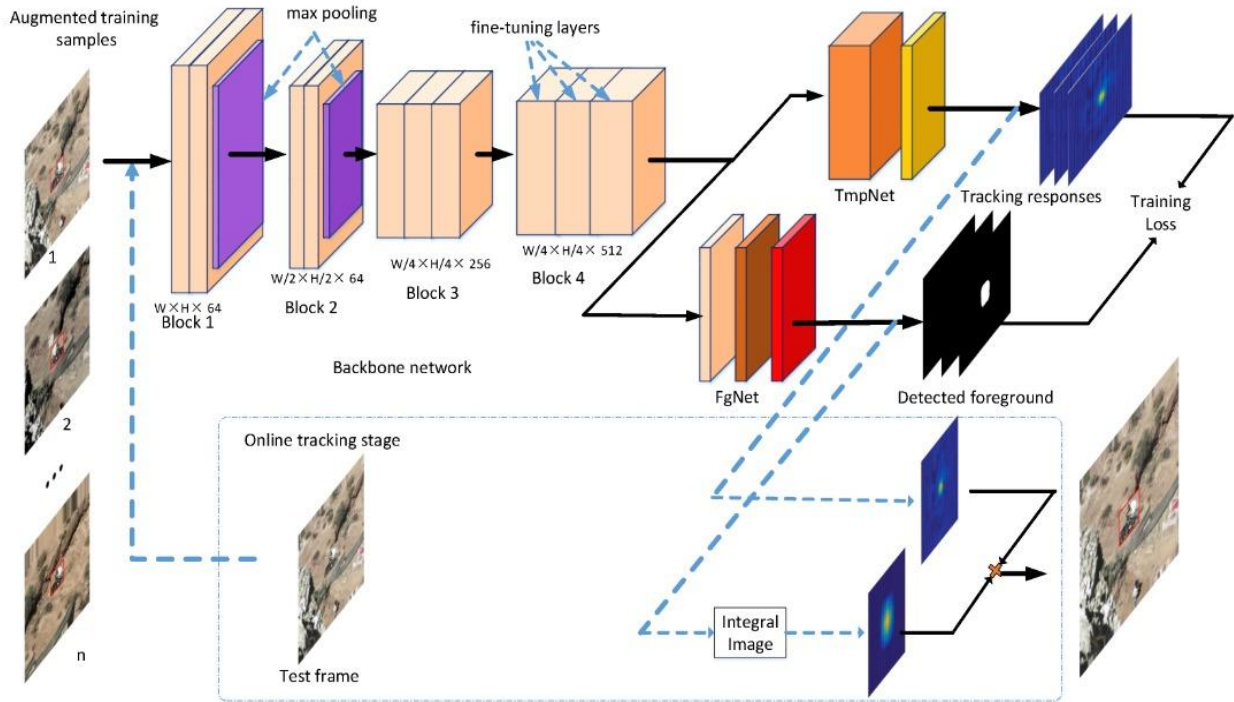


Fig. 2 Object tracking with template tracking

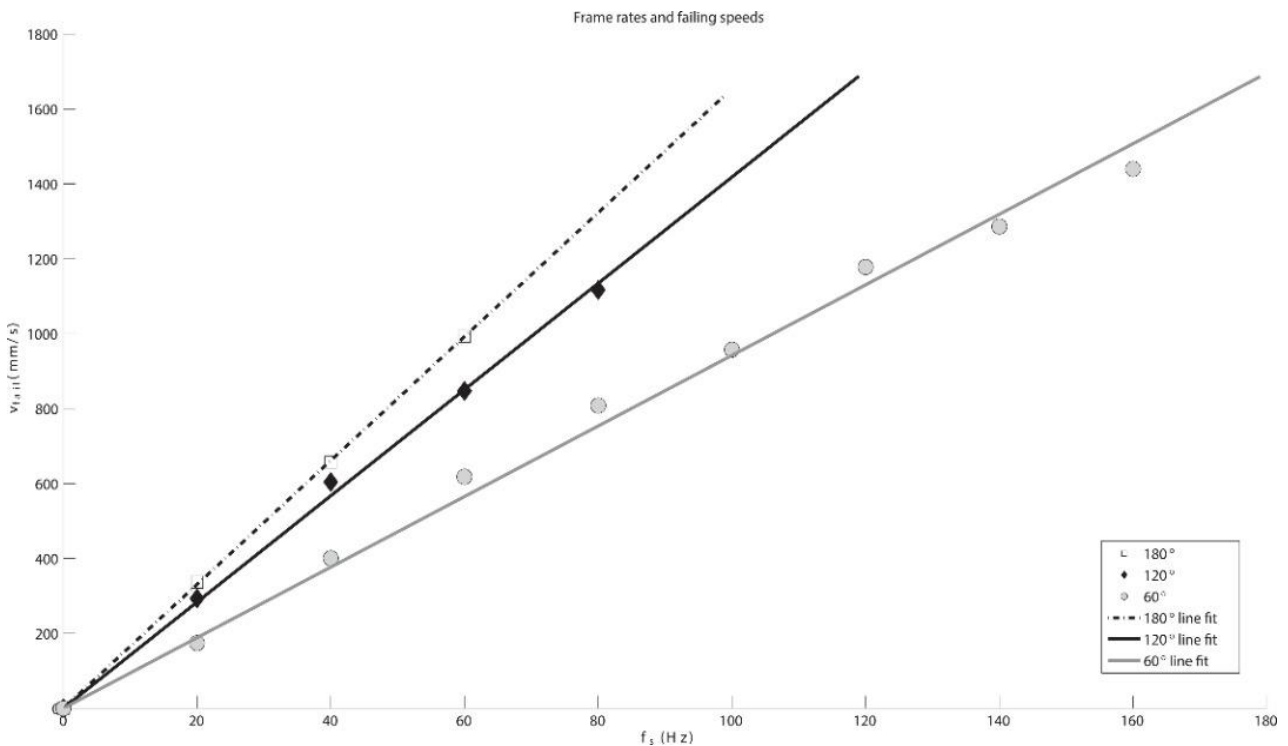


Fig. 3 Object tracking with template tracking

motion-based methods to achieve the maximum results. In the case of tennis tracking, since there could be multiple moving objects as matches, fans, promotional symbols, and trees, the motion detail in the image series can be very complicated and ambiguous (Assfalg *et al.* 2002, D’Orazio *et al.* 2002, Friedman and Russell 2013, Wang *et al.* 2021).

The emphasis of contemporary higher education has

been on how to boost teaching content in higher physical education. The level of physical education is substantially expressed in college physical instruction by the quality of university education. The main measures to increase the quality of education and teaching are physical teaching assessment, which is especially important for the implementation of a quality assessment framework for

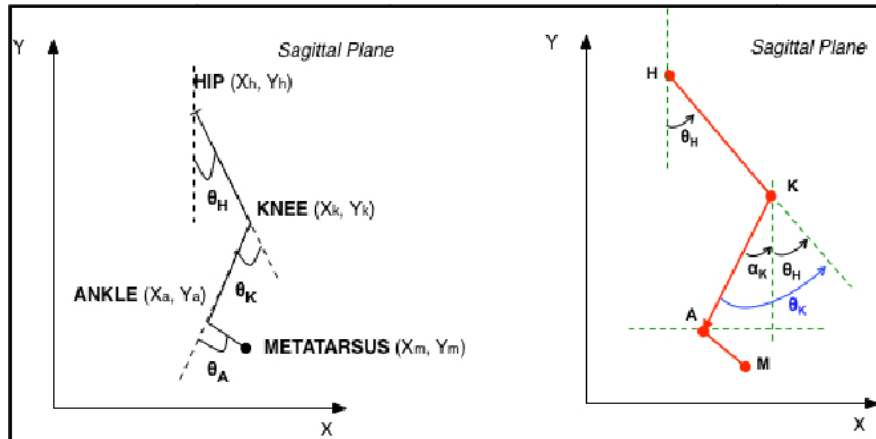


Fig. 4 Analysis of knee joint motion in flat serve using entropy and unascertained measurement theory

science and logical college teaching (Mohammadhassani *et al.* 2013a, Togholi *et al.* 2016, Jiang *et al.* 2018, Sadeghipour Chahnasir *et al.* 2018, Chen *et al.* 2019, Safa *et al.* 2020, Shariati *et al.* 2020e). Physical teaching is a mixture of the complex teaching and learning process, and certain factors are not the same that could influence the consistency of teaching along with the effect of these factors (Mohammadhassani *et al.* 2014, Shariati *et al.* 2019c, 2020c, 2021b). Therefore, it is impossible to use a statistical term to represent the outcomes of the physical training assessment, because it is a non-linear description, which has created considerable complexes for a systematic assessment (Zuo *et al.* 2013, Mansouri *et al.* 2016, Zhang *et al.* 2018, Shariati *et al.* 2019d, Shariati *et al.* 2019f, Yazdani *et al.* 2020). The physical education level is the subject in higher development in physical education. Therefore, the implementation requirements of the modern century should be fulfilled with the establishment of a framework to evaluate the teaching standard and increase the technical quality of the teaching appraisal system. A successful tool for assessing the standard of teaching physical training plays a key role in encouraging trainers to train and to improve the quality of training. An approach to combining entropy weight and expert preferences is employed, with reasonable fluctuations in black start assessment indices, and with the help of fluid appraisal data and a fluctuation of extensive evaluation, the sorting of the schemes is carried out in conjunction with the respective superiors and inferiors. In the evaluation of third-party logistics providers, some researchers investigated a new information granulation model. Conventional fuzzy evaluation approaches are useful but time consuming. Objective measurements are rational, but it is often difficult to explain their results (Ebrahimi and Shafiei 2017, Ebrahimi *et al.* 2017, Ehyaei *et al.* 2017, Ghadiri *et al.* 2017a, b, c, d, e, Mirjavadi *et al.* 2017a, b, c, d, Shafiei *et al.* 2017a, b, c, d, 2019, 2020, Shafiei and Kazemi 2017a, b, Shivanian *et al.* 2017, Azimi *et al.* 2018, Shafiei and She 2018). To promote clustering accuracy, a low complex and accurate modularity Q model under information entropy (IE) is suggested (Xiaolong *et al.* 2012, Junkun *et al.* 2020, Lv and Qiao 2020, He *et al.* 2021a). Duan *et al.* (year) have developed a complex method

of non-serial manufacturing systems on the basis of the entropy model of system-angle information theory. The entropy weight comprises of the following steps: building a factor assessment system, setting up the field of eco-security classification factors, constructing an entropy model and analysis of matter elements, calculating the relevance between the eco-security factor and land, and calculating the weight of all variables (Yu *et al.* 2012, Wang *et al.* 2020b). A new entropy based method and TOPSIS to synchronize the evaluation of the supply chain was proposed by Li *et al.* (2019b). Two steps are based on the model. Firstly, for the synchronized supply chain, a detailed comparison is made of many index systems (Zhiyong *et al.* 2012, Shi *et al.* 2017).

## 2. Entropy-unascertained measure theory

Wang Guangyuan proposed the principle of unknown information and its mathematical processing as a modern information theory in 1990. Uncertain knowledge means that people are not sufficient to understand the actual quantity or state that allows the brains of decision-makers or evaluators to be subjectively and cognitive uncertain. Both processes with behavioral causes can be assumed to be uncertain. Nevertheless, Liu *et al.* (2020d) set a statistical theory uncertainly to explain the uncertain condition of the item in measurable terms and proposed an estimation model for an uncertain theory of measurement to describe a matter of an uncertain nature between 0 and 1. The uncertain theory for measurements was developed rapidly, implemented widely in several fields, including assessment of reliability, assessment of security risk, social development evaluation, quotation bidding, and project implementation followed by uncertain measures (Azimi *et al.* 2016, Ebrahimi and Shafiei 2016, Ghadiri and Shafiei 2016a, b, c, Ghadiri *et al.* 2016a, b, c, d, Shafiei *et al.* 2016a, b, c, d, e, f, g). Considering several complexities in the current construction renovation scheme, the unclear theory of the measure will examine these uncertainties. This study utilizes the uncertain theory of the measure to determine the renovation project model for construction safety risk assessments.

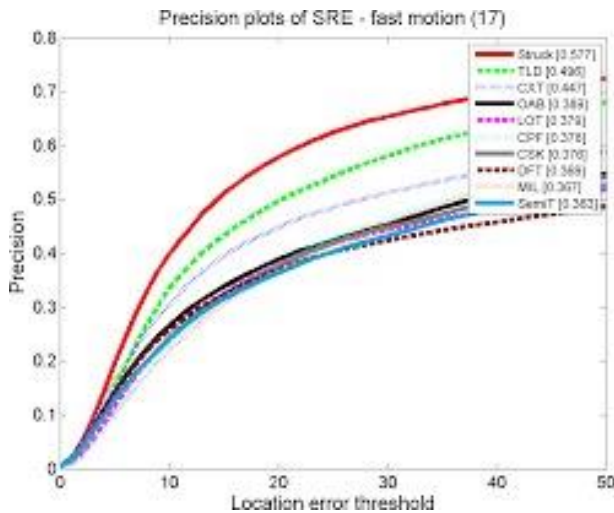


Fig. 5 Online object tracking

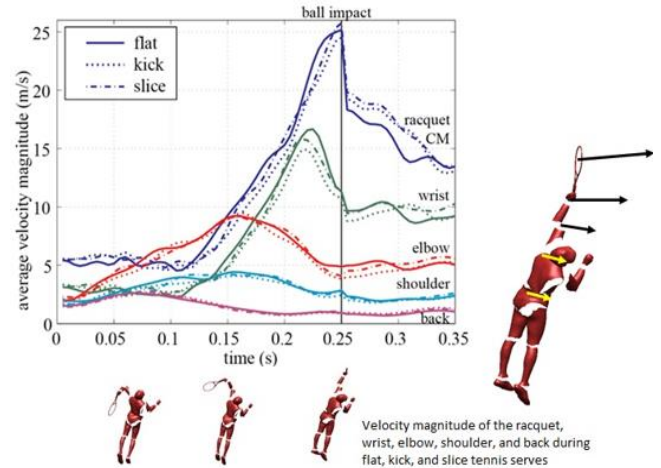


Fig. 7 Various motion velocity in a flat serve

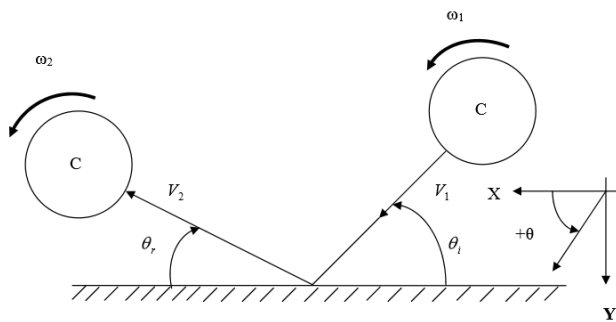


Fig. 6 Kinematic parameters of the tennis ball striking the non-smooth surface

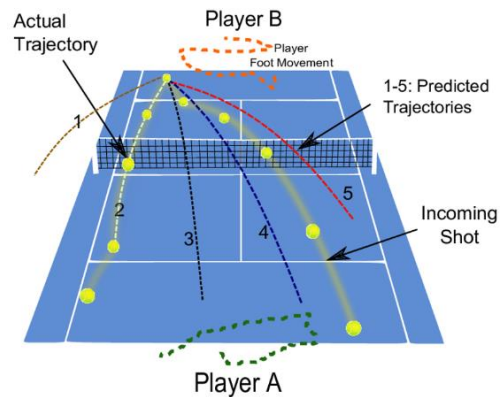


Fig. 8 Flat shot variations

### 3. Entropy

The human movement variability is explained as motor performance variations over multiple repetitions for the same task (Hong and Bartlett 2008, Kudo and Ohtsuki 2008, Pan *et al.* 2020). Despite similarities between repetitions, the multiple constraints inherent to the environment, the task and even the athlete’s body lead to inevitable differences, thus resulting in a certain degree of variability (Bernstein 1967, Huang *et al.* 2021d). From an evaluation perspective, the human movement oscillations can be evaluated, as any other time-series, by benefiting from entropy-based techniques which allow to identify the variability in a spatiotemporal perspective (Stergiou 2004, Zuo *et al.* 2015).

### 4. Problem statement

There are several concerns with identifying and tracking the ball in a tennis video (Guan *et al.* 2019). We present the investigations of two models for tracking the tennis ball in this report (Liu *et al.* 2021a). This scheme is formed to match the speed of accelerated processing. This device has to work successfully, i.e., the image processing speed can keep up with the video input speed (Jiang *et al.* 2018). If a high resolution and high frame rate camera is chosen could be challenging (Zuo *et al.* 2017, Li *et al.* 2020a). An

appropriate tracking algorithm is needed to process such a large volume of image data quickly (Yang and Sowmya 2015, Wang *et al.* 2020a). The visibility of the tennis ball may be ambiguous between both frames, considering the high ball speed, ambient differences (e.g. brightness, contrast and shadow) and the presence of other moving objects (e.g. promotional symbols) (Ran *et al.* 2020). A robust object recognition method is required to compromise with different levels of visibility (Long *et al.* 2015). This research has used entropy and uncertain estimation to determine the movement of the ball and the efficiency of the athlete more precisely than conventional approaches, which enable coaches and athletes to improve their skills effectively (Niu *et al.* 2020, Wang *et al.* 2020c).

### 5. Methodology

In this section, let's increase the complexity of the human motor execution from a pendulum to a ballistic-like motion. For the tennis serve case, a non-traditional analysis of motor variability may help revealing or uncovering its complex structure, which is undetectable using conventional linear measures, such as amplitude or standard deviation (Hausdorff *et al.* 1996, Post *et al.* 2000, Araújo *et al.* 2004, Alam *et al.* 2020a). The sample consisted of 6 adult female

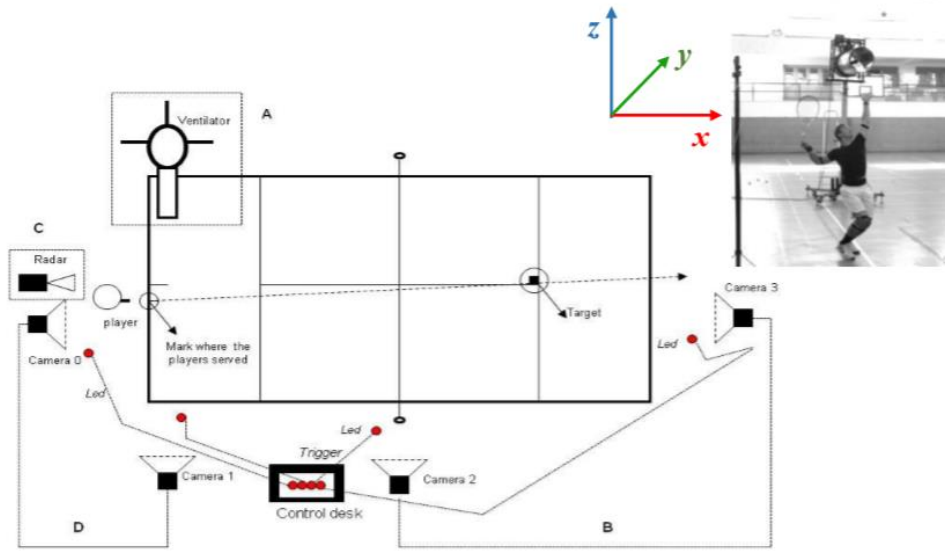


Fig. 9 Accuracy registration device

Table 1 Tracking result for data

Method	TR%	TR range	Err.	Err. range	fps	Fps range
CT	78.43%	0-100%	18.40	4-75	99.99	64-122
FCT	16.14%	0-74%	58.70	16-92	119.73	73-151
HT	94.12%	36-100%	15.30	3-256	4.60	4-5
IVT	73.50%	18-100%	85.75	2.1-450	63.38	51-70
KCF	100%	-	4.55	1.5-7.5	979.97	728-1240
LRS	20.52%	2-47%	295.43	76-540	8.80	7.8-9.5
MIL	92.81%	24-100%	11.53	3.0-138	0.56	0.4-0.7
RSCM	85.84%	41-100%	17.82	2.3-126	2.50	2.0-2.8
SRPCA	82.65%	25-100%	72.40	1.7-356	10.52	8.4-12.50
STC	100%	-	5.14	2.5-7.0	1294.12	1156-1340
struck	100%	-	4.73	1.5-6.5	118.56	100-154
TLD	67.50	16-100%	43.55	4.4-140	16.50	8.5-24

tennis players. The movement under study was the flat first serve from behind the T point 50 cm away from the center mark. All the participants should serve in the highest speed while pointing to the intersection between the center line and service line (T-point) (Zhou *et al.* 2018, Ding *et al.* 2020, He *et al.* 2020, Wu *et al.* 2020, Xie *et al.* 2020, Cao *et al.* 2021a, b, c, Li *et al.* 2021, Liu *et al.* 2021b, e, Lv *et al.* 2021, Sun *et al.* 2021, Wu *et al.* 2021). Also, they were all required to execute 20 tennis serves, without instructional or wind restrictions. Afterwards, they were then asked to execute four sets of 20 serves under various practice conditions (Xie *et al.* 2018).

## 6. Result and discussion

### 6.1 Result and discussion

Dominant motion functionality is applied to assist key-frame recognition in sport videos (Liu *et al.* 2003, Xu *et al.*

2020). Whilst, it was found that applying dominant motion feature, global camera motion can be puzzled. So, a motion entropy is the efficient calculation and efficient in rejecting false alarms (Suthaharan *et al.* 1999, Zhao *et al.* 2020). Entropy Motion Value (EMV) is defined as follows:

$$\text{EntropyMotionValue} = \sum_k \text{MagWeight}_k \cdot \text{Entropy} \quad (1)$$

where  $k$  is the index of  $\text{AngNum}$  equally partitioned quantized angles each with  $2\pi/\text{AngNum}$  radians. Empirically, it is found  $\text{AngNum} = 16$  yield satisfactory performance (Alam *et al.* 2020b).

$k^{\text{th}}$  angle is defined as

$$\text{Entropy}_k = -p_k \cdot \log(P_k) \quad (2)$$

$p_k$  = A fraction of motion vectors in a frame with an appropriate angle within the quantified  $k^{\text{th}}$  angle. The directivity entropy weighting is:

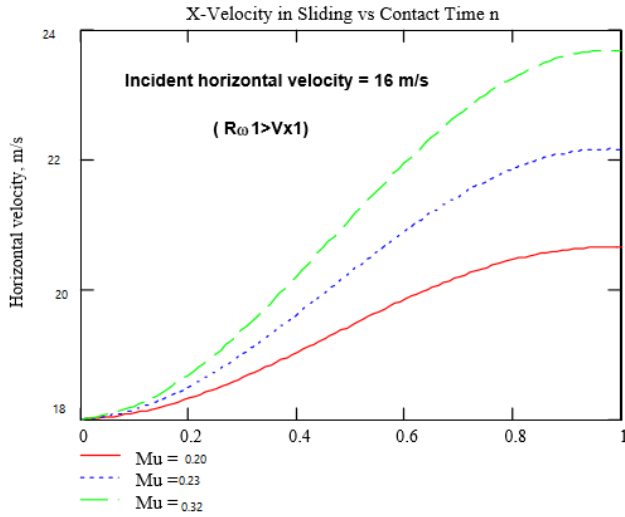


Fig. 10 Horizontal velocity during contact as a function of time

$$MagWeight_k = \frac{Magnitude_k}{\sum_k Magnitude_k} \quad (3)$$

Magnitude denotes the number of motion vector magnitudes whose angle lies beyond the quantized angle of  $k^{th}$  (Zhang *et al.* 2018). The EMV is comparable to the perceived motion energy described (Liu *et al.* 2003) that both the magnitudes and the angle of motion vectors are used in a video frame to describe the sports content. However, they are still different in many significant ways: focused on entropy of motion directivity to reduce the influence of global motion and to affect uncertain object movements (Yow *et al.* 1995, Zhong and Chang 1997). Near the second 400, there was a sudden attacking goal incident. Due to the EMV, the object motion directive was not only represented by the PME, but also by EMV.

### 6.2 Motion pattern recognition

The goal of motion pattern is to align EMV curve with semantically important sports events to segment the video sequence on the basis of semantic content. Regarding EMV curve, positive slope line segments normally is in important sports events, but not negative slope line segments.

### 6.3 Composite UM of multiple indices

$v_{ik}$  shows the level of assessment object  $I_i$  belongs to  $k$ -th grade of evaluation ( $\Delta_k$ ). If  $v_{ik}$  is equal to  $v(I_i \in \Delta_k)$ ,  $v_{ik}$  is termed the composite UM of multiple indices (Zhu *et al.* 2018). After gaining the identification weight and single index matrix, considering the meaning of identification weight, the composite UM of multiple indices can be written as

$$v_{ik} = \sum_{j=1}^m \omega_j v_{ik}^j (i = 1, 2, \dots, n, k = 1, 2, \dots, p) \quad (4)$$

where  $v_{ik}$  satisfies  $0 \leq v_{ik} \leq 1$  and  $\sum_{k=1}^p v_{ik} =$

$$\sum_{k=1}^p \sum_{j=1}^m \omega_j v_{ik}^j = \sum_{j=1}^m (\sum_{k=1}^p v_{ik}^j) \omega_j = 1$$

### 6.4 Principle of identification

Since  $\Delta_k$  is “better” than  $\Delta_{k+1}$ , the classification of comment ranks ( $\Delta_1, \Delta_2, \dots, \Delta_p$ ) is ordered say the highest measure identification (MMI) principle is not available (Chen *et al.* 2020, Zhou and Li 2012). If the  $e$  evaluation space meets  $\Delta_1, \Delta_2, \dots, \Delta_p$ , Let

$$k_0 = \min \left\{ k: \sum_{s=1}^k v_{is}(\Delta_i) \geq \delta, 1 \leq k \leq p \right\} \quad (5)$$

$$\varphi_i = \text{the } k_0 \text{- section appraisal grade } \Delta_{k_i}$$

The confidence that the grade of  $\varphi_i$  is not higher than  $k_0$  is  $\lambda$  or the confidence that the grade of sample  $\varphi_i$  is higher than  $k_0$  is  $1 - \lambda$ . Suppose that the score value of  $C_t$  is  $I_t$ ,  $J_{\Delta_i}$  is (Ni *et al.* 2019b, Feng *et al.* 2020):

$$J_{\Delta_i} = \sum_{i=1}^p I_t \cdot \mu_{it}$$

$j_{\Delta_i}$  = the unascertained superiority degree of evaluation object  $\Delta_i$ ,

$o J = (j_{\Delta_1}, j_{\Delta_2}, \dots, j_{\Delta_p})$   
= vector of unascertained superiority degree

### 6.5 Definition of unascertained measure

It is assumed the assessment object  $X = \{X_1, X_2, \dots, X_n\}$  and the assessment index set  $I = \{I_1, I_2, \dots, I_m\}$ . If  $x_{ij}$  shows the measured value of  $i$ th assessment object  $X_i$  regarding the  $j$ th assessment index  $I_j$ , then  $X_i$  is defined as an  $m$ -dimensional vector of  $\{x_{i1}, x_{i2}, \dots, x_{im}\}$ . Also, it was supposed that the assessment grade space  $U = \{C_1, C_2, \dots, C_p\}$ , and  $C_k$  ( $k = 1, 2, \dots, p$ ) is the  $k$  assessment grade. If  $k$  is more than  $k + 1$  in safety risk,  $C_k > C_{k+1}$ . If  $C_1 > C_2 > \dots > C_p$  or  $C_1 < C_2 < \dots < C_p$  is reached ( $(C_1, C_2, \dots, C_p)$  = an ordered segmentation class of assessment space  $U$ ).

$$0 \leq \mu(x_{ij} \in C_k) \leq 1 \quad (i = 1, 2, \dots, n, j = 1, 2, \dots, m, k = 1, 2, \dots, p) \quad (7)$$

$$\mu(x_{ij} \in U) = 1 (I = 1, 2, \dots, N, J = 1, 2, \dots, M) \quad (8)$$

$$\mu|x_{ij} \in U_{i=1}^k C_1| = \sum_{i=1}^k \mu(x_{ij} \in C_1) (k = 1, 2, \dots, p) \quad (9)$$

Eq. (7) = non-negative boundedness, Eq. (8) = normalization, Eq. (9) = additivity. If  $\mu$  satisfies Eqs. (7)-(9), then  $\mu$  is termed as unascertained measure.

### 6.6 Single-index unascertained measure matrix

For every assessment object  $X_i$  ( $i = 1, 2, \dots, n$ ),  $(\mu_{ijk})_{m \times p}$  is named as the single-index measure assessment matrix of  $X_i$  as Eq. (10).

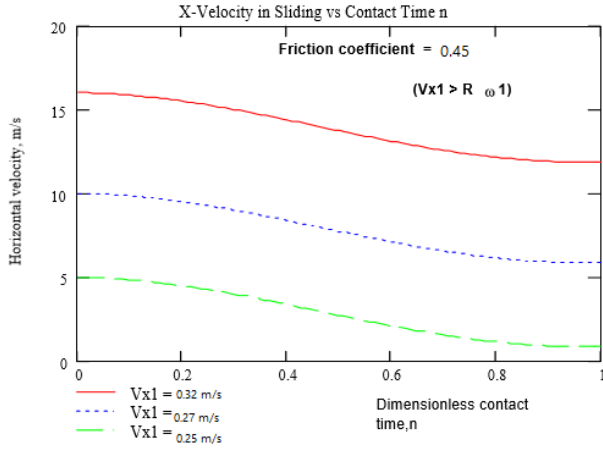


Fig. 11 Horizontal velocity during contact as a function of time (effect of initial velocity)

$$(\mu_{ijk}) = \begin{bmatrix} \mu_{i11} & \mu_{i12} & \cdots & \mu_{i1p} \\ \mu_{i21} & \mu_{i22} & \cdots & \mu_{i2p} \\ \vdots & \vdots & \ddots & \vdots \\ \mu_{im1} & \mu_{im2} & \cdots & \mu_{imp} \end{bmatrix} \quad (10)$$

Function expression of linear type

$$\begin{cases} \mu_i(x) = \begin{cases} \frac{-x}{a_{i+1} - a_i} + \frac{a_{i+1}}{a_{i+1} - a_i} & a_i < x < a_{i+1} \\ 0 & x > a_{i+1} \\ 0 & x \leq a_i \end{cases} \\ \mu_{i+1}(x) = \begin{cases} \frac{-x}{a_{i+1} - a_i} + \frac{a_{i+1}}{a_{i+1} - a_i} & a_i < x < a_{i+1} \\ 0 & x > a_{i+1} \\ 0 & x \leq a_i \end{cases} \end{cases} \quad (11)$$

$$\begin{cases} \mu_i(x) = \begin{cases} 1 - \left(\frac{x - a_i}{a_{i+1} - a_i}\right)^2 & a_i < x \leq a_{i+1} \\ 0 & x > a_{i+1} \\ 0 & x \leq a_i \end{cases} \\ \mu_{i+1}(x) = \begin{cases} \left(\frac{x - a_i}{a_{i+1} - a_i}\right)^2 & a_i < x \leq a_{i+1} \\ 0 & x > a_{i+1} \\ 0 & x \leq a_i \end{cases} \end{cases} \quad (12)$$

6.7 Function expression of exponential type

$$\begin{cases} \mu_i(x) = \begin{cases} 1 - \frac{1 - e^{x-a_i}}{1 - e^{a_{i+1}-a_i}} & a_i < x \leq a_{i+1} \\ 0 & x > a_{i+1} \\ 0 & x \leq a_i \end{cases} \\ \mu_{i+1}(x) = \begin{cases} \frac{1 - e^{x-a_i}}{1 - e^{a_{i+1}-a_i}} & a_i < x \leq a_{i+1} \\ 0 & x > a_{i+1} \\ 0 & x \leq a_i \end{cases} \end{cases} \quad (13)$$

6.8 Function expression of sinusoidal type

$$\begin{cases} = \begin{cases} \frac{1}{2} - \frac{1}{2} \sin \frac{\pi}{a_{i+1} - a_i} \left(x - \frac{a_{i+1} - a_i}{2}\right) & a_i < x \leq a_{i+1} \\ 0 & x > a_{i+1} \\ 0 & x \leq a_i \end{cases} \\ = \begin{cases} \frac{1}{2} + \frac{1}{2} \sin \frac{\pi}{a_{i+1} - a_i} \left(x - \frac{a_{i+1} - a_i}{2}\right) & a_i < x \leq a_{i+1} \\ 0 & x > a_{i+1} \\ 0 & x \leq a_i \end{cases} \end{cases} \quad (14)$$

Table 2 Tracking result for obtained data

Effect factors	Physical training quality score				
	Bad	Poor	Medium	Good	Excellent
Attending Rate	$\leq 0.4$	0.41-0.55	0.36-0.65	0.86-0.95	$\geq 0.96$
Test results of athletes	$\leq 40$	34-69	30-79	50-89	$\geq 80$
Expert Evaluation	$\leq 40$	51-69	60-79	40-69	$\geq 80$
Athletes verifying	$\leq 54$	43-67	35-78	45-67	$\geq 90$
Team's verifying	$\leq 70$	56-85	56-60	41-74	$\geq 70$
Training scope	Very narrow	Narrow	Ordinary	Wide	$\geq 95$

$$H_j = -t \sum_{k=1}^p q_{ijk} \ln q_{ijk}$$

$$\omega = \frac{d_j}{\sum_{j=1}^m d_j} = \frac{1 - H_j}{m - \sum_{j=1}^m H_j} \quad (15)$$

$$\mu_{ij} = \sum_{j=1}^m \omega_j \cdot \mu_{ij} \quad (i = 1, 2, \dots, n, k = 1, 2, \dots, p)$$

$$p_0 = \min \left| p: \sum_{k=1}^p \mu_{ik} > \lambda i, i = 1, 2, \dots, n \right|$$

$$\mu_{ij1} = \begin{cases} 0 & x_{ij} \leq 82.5 \\ \frac{x_{ij} - 82.5}{7.5} & 82.5 < x_{ij} \leq 90 \\ 1 & x_{ij} > 90 \end{cases}$$

$$\mu_{ij2} = \begin{cases} 0 & x_{ij} \leq 67.5 \text{ or } x_{ij} > 90 \\ \frac{x_{ij} - 67.5}{15} & 67.5 < x_{ij} \leq 82.5 \\ \frac{90 - x_{ij}}{7.5} & 82.5 < x_{ij} \leq 90 \end{cases} \quad (16)$$

$$\mu_{ij3} = \begin{cases} 0 & x_{ij} \leq 60 \text{ or } x_{ij} > 82.5 \\ \frac{x_{ij} - 60}{7.5} & 60 < x_{ij} \leq 67.5 \\ \frac{82.5 - x_{ij}}{15} & 67.5 < x_{ij} \leq 82.5 \\ 1 & x_{ij} \leq 60 \end{cases}$$

$$\mu_{ij4} = \begin{cases} \frac{67.5 - x_{ij}}{7.5} & 60 < x_{ij} \leq 67.5 \\ 0 & x_{ij} > 67.5 \end{cases} \quad (17)$$

## 7. Conclusions

The conclusion reached was that nonlinear approaches are very beneficial for analyzing human movement within the context of sports. In general, entropy-based measurements can be thought of as a critical tool for analyzing human variability, as they compensate for the drawbacks inherent in linear approaches for calculating motor performance, such as the standard deviation, the inter-quartile scale, and a variety of other classical alternatives. Though it is worth noting that the relevance of

linear approaches in sports science was not minimized, but rather other nonlinear techniques were recommended to further our understanding of the science of human movement. The information entropy and unascertained measurement theory are discussed in this article in order to better understand human uncertainty in the context of tennis (ballistic like movement) (Ma and Xu 2020). The results have substantial practical implications for the area of sports training, as they reveal that an athlete may maintain his or her performance by using a variety of information-movement combinations with varying degrees of unpredictability, regularity, and complexity. This demonstrates the complexity inherent in normal variability, highlighting motor control characteristics that athletes and coaches must quantify and, more importantly, comprehend. Additionally, the inclusion of notions based on nonlinear dynamics provides a fresh perspective on how preparation in general might be arranged. As a consequence, using optimum or conventional procedures may be insufficient, and a variety of nonlinear strategies should be examined that may be implemented and adjusted to the unique characteristics of each athlete and motion tracking system.

## References

- Abedini, M. and Zhang, C. (2020), "Performance assessment of concrete and steel material models in ls-dyna for enhanced numerical simulation, a state of the art review", *Arch. Comput. Method. E.*, 1-22. <https://doi.org/10.1007/s11831-020-09483-5>.
- Abedini, M., Zhang, C., Mehrmashhadi, J. and Akhlaghi, E. (2020), "Comparison of ALE, LBE and pressure time history methods to evaluate extreme loading effects in RC column", *Structures*, **28**, 456-466. <https://doi.org/10.1016/j.istruc.2020.08.084>.
- Afshar, A., Jahandari, S., Rasekh, H., Shariati, M., Afshar, A. and Shokrgozar, A. (2020), "Corrosion resistance evaluation of rebars with various primers and coatings in concrete modified with different additives", *Constr. Build. Mater.*, **262**(30), 120034. <https://doi.org/10.1016/j.conbuildmat.2020.120034>.
- Alam, Z., Zhang, C. and Samali, B. (2020a), "Influence of seismic incident angle on response uncertainty and structural performance of tall asymmetric structure", *Struct. Des. Tall Spec.*, **29**(12), e1750. <https://doi.org/10.1002/tal.1750>.
- Alam, Z., Zhang, C. and Samali, B. (2020b), "The role of viscoelastic damping on retrofitting seismic performance of asymmetric reinforced concrete structures", *Earthq. Eng. Eng. Vib.*, **19**(1), 223-237. <https://doi.org/10.1007/s11803-020-0558-x>.
- Alipour, M., Torabi, M.A., Sareban, M., Lashini, H., Sadeghi, E., Fazaeli, A., Habibi, M. and Hashemi, R. (2020), "Finite element and experimental method for analyzing the effects of martensite morphologies on the formability of DP steels", *Mech. Based Des. Struct.*, **48**(5), 525-541. <https://doi.org/10.1080/15397734.2019.1633343>.
- Arabnejad Khanouki, M.M., Ramli Sulong, N.H. and Shariati, M. (2010), "Behavior of through beam connections composed of cfsst columns and steel beams by finite element studying", *Adv. Mater. Res.*, **168-170**, 2329-2333. <https://doi.org/10.4028/www.scientific.net/AMR.168-170.2329>.
- Araújo, D., Davids, K., Bennett, S.J., Button, C. and Chapman, G. (2004), *19. Emergence of Sport Skills Under Constraints in Skill Acquisition in Sport: Research, Theory and Practice*, Routledge, London, U.K.
- Assfalg, J., Bertini, M., Colombo, C. and Bimbo, A.D. (2002), "Semantic annotation of sports videos", *IEEE MultiMedia*, **9**(2), 52-60. <https://doi.org/10.1109/93.998060>.
- Azimi, M., Mirjavadi, S.S., Shafiei, N. and Hamouda, A.M.S. (2016), "Thermo-mechanical vibration of rotating axially functionally graded nonlocal Timoshenko beam", *Appl. Phys. A*, **123**(1), 104. <https://doi.org/10.1007/s00339-016-0712-5>.
- Azimi, M., Mirjavadi, S.S., Shafiei, N., Hamouda, A.M.S. and Davari, E. (2018), "Vibration of rotating functionally graded Timoshenko nano-beams with nonlinear thermal distribution", *Mech. Adv. Mater. Struct.*, **25**(6), 467-480. <https://doi.org/10.1080/15376494.2017.1285455>.
- Bai, Y., Alzahrani, B., Baharom, S. and Habibi, M. (2020), "Semi-numerical simulation for vibrational responses of the viscoelastic imperfect annular system with honeycomb core under residual pressure", *Eng. Comput.*, 1-26. <https://doi.org/10.1007/s00366-020-01191-9>.
- Barron, J.L., Fleet, D.J., Beauchemin, S.S. and Burkitt, T. (1992), "Performance of optical flow techniques", *Syst. Exp.*, **12**, 43-77. <https://doi.org/10.1007/BF01420984>.
- Bennett, N., Burrige, R. and Saito, N. (1999), "A method to detect and characterize ellipses using the Hough transform", *IEEE T. Pattern Anal.*, **21**(7), 652-657. <https://doi.org/10.1109/34.777377>.
- Bernstein, N. (1967), *The Co-ordination and Regulation of Movements*, PergamonPress Ltd., Oxford, U.K.
- Bradski, G.R. (1998), "Real time face and object tracking as a component of a perceptual user interface", *Proceedings Fourth IEEE Workshop on Applications of Computer Vision. WACV'98 (Cat. No. 98EX201)*, Newjersey, U.S.A., August.
- Cao, B., Gu, Y., Lv, Z., Yang, S., Zhao, J. and Li, Y. (2021a), "RFID reader anticollision based on distributed parallel particle swarm optimization", *IEEE Internet Thing J.*, **8**(5), 3099-3107. <https://doi.org/10.1109/IJOT.2020.3033473>.
- Cao, B., Li, M., Liu, X., Zhao, J., Cao, W. and Lv, Z. (2021b), "Many-objective deployment optimization for a drone-assisted camera network", *IEEE T. Netw. Sci. Eng.*, **8**(4), 2756-2764. <https://doi.org/10.1109/TNSE.2021.3057915>.
- Cao, B., Zhang, W., Wang, X., Zhao, J., Gu, Y. and Zhang, Y. (2021c), "A memetic algorithm based on two\_Arch2 for multi-depot heterogeneous-vehicle capacitated arc routing problem", *Swarm Evol. Comput.*, **63**, 100864. <https://doi.org/10.1016/j.swevo.2021.100864>.
- Chen, H., Qiao, H., Xu, L., Feng, Q. and Cai, K. (2019), "A fuzzy optimization strategy for the implementation of RBF LSSVR model in vis-NIR analysis of pomelo maturity", *IEEE T. Ind. Inform.*, **15**(11), 5971-5979. <https://doi.org/10.1109/TII.2019.2933582>.
- Chen, Z., Wang, J., Ma, K., Huang, X. and Wang, T. (2020), "Fuzzy adaptive two-bits-triggered control for nonlinear uncertain system with input saturation and output constraint", *Int. J. Adapt. Control.*, **34**(4), 543-559. <https://doi.org/10.1002/acs.3098>.
- Cheshmeh, E., Karbon, M., Eyvazian, A., Jung, D.W., Habibi, M. and Safarpour, M. (2020), "Buckling and vibration analysis of FG-CNTRC plate subjected to thermo-mechanical load based on higher order shear deformation theory", *Mech. Based Des. Struct.*, 1-24. <https://doi.org/10.1080/15397734.2020.1744005>.
- D'Orazio, T., Ancona, N., Cicirelli, G. and Nitti, M. (2002), "A ball detection algorithm for real soccer image sequences", *Proceedings of the 2002 International Conference on Pattern Recognition*, Quebec City, Canada, August.
- Dai, Z.C., Jiang, Z.Y., Zhang, L. and Habibi, M. (2021a), "Frequency characteristics and sensitivity analysis of a size-dependent laminated nanoshell", *Adv. Nano. Res.*, **10**(2), 175-189. <https://doi.org/10.12989/anr.2021.10.2.175>.
- Dai, Z.C., Zhang, L., Bolandi, S.Y. and Habibi, M. (2021b), "On

- the vibrations of the non-polynomial viscoelastic composite open-type shell under residual stresses”, *Compos. Struct.*, **263**, 113599. <https://doi.org/10.1016/j.compstruct.2021.113599>.
- Das, M. and Anand, J. (1995). “Robust edge detection in noisy images using an adaptive stochastic gradient technique”, *Proceedings of the International Conference on Image Processing*, Washington D.C., U.S.A.
- Davoodnabi, S.M., Mirhosseini, S.M. and Shariati, M. (2021), “Analyzing shear strength of steel-concrete composite beam with angle connectors at elevated temperature using finite element method”, *Steel Compos. Struct.*, **40**(6), 853-868. <https://doi.org/10.12989/scs.2021.40.6.853>.
- Ding, L., Huang, L., Li, S., Gao, H., Deng, H., Li, Y. and Liu, G. (2020), “Definition and application of variable resistance coefficient for wheeled mobile robots on deformable terrain”, *IEEE T. Robot.*, **36**(3), 894-909. <https://doi.org/10.1109/TRO.2020.2981822>.
- Eaton, R. and Scassellati, B. (2000), “ViSIT: Visual surveillance and interaction tracking”, *Social Robotics Lab. Yale Univ.*, **6511**, New Haven, Connecticut, U.S.A.
- Ebrahimi, F., Mohammadi, K., Barouti, M.M. and Habibi, M. (2019), “Wave propagation analysis of a spinning porous graphene nanoplatelet-reinforced nanoshell”, *Wave. Random Complex.*, 1-27. <https://doi.org/10.1080/17455030.2019.1694729>.
- Ebrahimi, F. and Shafiei, N. (2016), “Application of Eringen’s nonlocal elasticity theory for vibration analysis of rotating functionally graded nanobeams”, *Smart Struct. Syst.* **17**(5), 837-857. <https://doi.org/10.12989/sss.2016.17.5.837>.
- Ebrahimi, F. and Shafiei, N. (2017), “Influence of initial shear stress on the vibration behavior of single-layered graphene sheets embedded in an elastic medium based on Reddy’s higher-order shear deformation plate theory”, *Mech. Adv. Mater. Struct.*, **24**(9), 761-772. <https://doi.org/10.1080/15376494.2016.1196781>.
- Ebrahimi, F., Shafiei, N., Kazemi, M. and Mousavi Abdollahi, S.M. (2017), “Thermo-mechanical vibration analysis of rotating nonlocal nanoplates applying generalized differential quadrature method”, *Mech. Adv. Mater. Struct.*, **24**(15), 1257-1273. <https://doi.org/10.1080/15376494.2016.1227499>.
- Ehyaeei, J., Akbarshahi, A. and Shafiei, N.J.A.i.n.r. (2017), “Influence of porosity and axial preload on vibration behavior of rotating FG nanobeam”, *Adv. Nano. Res.*, **5**(2), 141-169. <https://doi.org/10.12989/anr.2017.5.2.141>.
- Fazaeli, A., Habibi, M. and Ekrami, A.A. (2016), “Experimental and finite element comparison of mechanical properties and formability of dual phase steel and ferrite-pearlite steel with the same chemical composition”, *Metall. Eng.*, **19**(2), 84-93. <https://doi.org/10.22076/ME.2017.41458.1064>.
- Feng, S., Lu, H., Tian, P., Xue, Y., Lu, J., Tang, M. and Feng, W. (2020), “Analysis of microplastics in a remote region of the Tibetan Plateau: Implications for natural environmental response to human activities”, *Sci. Total Environ.*, **739**, 140087. <https://doi.org/10.1016/j.scitotenv.2020.140087>.
- Friedman, N. and Russell, S. (2013), “Image segmentation in video sequences: A probabilistic approach”, *arXiv:1302.1539*. <https://arxiv.org/abs/1302.1539>.
- Ghabussi, A., Habibi, M., NoormohammadiArani, O., Shavalipour, A., Moayedi, H. and Safarpour, H. (2021), “Frequency characteristics of a viscoelastic graphene nanoplatelet-reinforced composite circular microplate”, *J. Vib. Control.*, **27**(1-2), 101-118. <https://doi.org/10.1177/1077546320923930>.
- Ghadiri, M., Hosseini, S.H.S. and Shafiei, N. (2016a), “A power series for vibration of a rotating nanobeam with considering thermal effect”, *Mech. Adv. Mater. Struct.*, **23**(12), 1414-1420. <https://doi.org/10.1080/15376494.2015.1091527>.
- Ghadiri, M., Shafiei, N. and Akbarshahi, A. (2016b), “Influence of thermal and surface effects on vibration behavior of nonlocal rotating Timoshenko nanobeam”, *Appl. Phys. A*, **122**(7), 673. <https://doi.org/10.1007/s00339-016-0196-3>.
- Ghadiri, M., Shafiei, N. and Alireza Mousavi, S. (2016c), “Vibration analysis of a rotating functionally graded tapered microbeam based on the modified couple stress theory by DQEM”, *Appl. Phys. A*, **122**(9), 837. <https://doi.org/10.1007/s00339-016-0364-5>.
- Ghadiri, M. and Shafiei, N. (2016a), “Nonlinear bending vibration of a rotating nanobeam based on nonlocal Eringen’s theory using differential quadrature method”, *Microsyst. Technol.*, **22**(12), 2853-2867. <https://doi.org/10.1007/s00542-015-2662-9>.
- Ghadiri, M. and Shafiei, N. (2016b), “Vibration analysis of a nano-turbine blade based on Eringen nonlocal elasticity applying the differential quadrature method”, *J. Vib. Control.*, **23**(19), 3247-3265. <https://doi.org/10.1177/1077546315627723>.
- Ghadiri, M. and Shafiei, N. (2016c), “Vibration analysis of rotating functionally graded Timoshenko microbeam based on modified couple stress theory under different temperature distributions”, *Acta Astronaut.*, **121**, 221-240. <https://doi.org/10.1016/j.actaastro.2016.01.003>.
- Ghadiri, M., Mahinzare, M., Shafiei, N. and Ghorbani, K. (2017a), “On size-dependent thermal buckling and free vibration of circular FG Microplates in thermal environments”, *Microsyst. Technol.*, **23**(10), 4989-5001. <https://doi.org/10.1007/s00542-017-3308-x>.
- Ghadiri, M., Shafiei, N. and Alavi, H. (2017b), “Thermo-mechanical vibration of orthotropic cantilever and propped cantilever nanoplate using generalized differential quadrature method”, *Mech. Adv. Mater. Struct.*, **24**(8), 636-646. <https://doi.org/10.1080/15376494.2016.1196770>.
- Ghadiri, M., Shafiei, N. and Alavi, H. (2017c), “Vibration analysis of a rotating nanoplate using nonlocal elasticity theory”, *J. Solid Mech.*, **9**(2), 319-337.
- Ghadiri, M., Shafiei, N. and Babaei, R. (2017d), “Vibration of a rotary FG plate with consideration of thermal and Coriolis effects”, *Steel Compos. Struct.* **25**(2), 197-207. <https://doi.org/10.12989/SCS.2017.25.2.197>.
- Ghadiri, M., Shafiei, N. and Safarpour, H. (2017e), “Influence of surface effects on vibration behavior of a rotary functionally graded nanobeam based on Eringen’s nonlocal elasticity”, *Microsyst. Technol.*, **23**(4), 1045-1065. <https://doi.org/10.1007/s00542-016-2822-6>.
- Ghadiri, M., Shafiei, N., Salekdeh, S.H., Mottaghi, P. and Mirzaie, T. (2016d), “Investigation of the dental implant geometry effect on stress distribution at dental implant–bone interface”, *J. Brazil. Soc. Mech. Sci. Eng.*, **38**(2), 335-343. <https://doi.org/10.1007/s40430-015-0472-8>.
- Ghazanfari, A., Assempour, A., Habibi, M. and Hashemi, R. (2016), “Investigation on the effective range of the through thickness shear stress on forming limit diagram using a modified Marciniak–Kuczynski model”, *Modares Mech. Eng.*, **16**(1), 137-143.
- Grimson, W.E.L., Stauffer, C., Romano, R. and Lee, L. (1998), “Using adaptive tracking to classify and monitor activities in a site”, *Proceedings of the 1998 IEEE Computer Society Conference on Computer Vision and Pattern Recognition (Cat. No. 98CB36231)*, California, U.S.A., August.
- Guan, Z., Xing, Q., Xu, M., Yang, R., Liu, T. and Wang, Z. (2019), “MFQE 2.0: A new approach for multi-frame quality enhancement on compressed video”, *IEEE T Pattern Anal.*, **43**(3), 949-963. <https://doi.org/10.1109/TPAMI.2019.2944806>.
- Guo, Y., Mi, H.L. and Habibi, M. (2021), “Electromechanical energy absorption, resonance frequency, and low-velocity impact analysis of the piezoelectric doubly curved system”, *Mech. Syst. Signal. Pr.*, **157**, 107723. <https://doi.org/10.1016/j.ymsp.2021.107723>.

- Gwiasda, K.E., Allender-Hagedorn, S., Chang, Y.Y., Eun, J.Y., Marino, P., Swales, J.M., Vanderbeke, D., Kamps, S., Bergmann, L.S. and Collins, A. (2000), "Bibliography: Relations of science to literature and the arts 1998", *Configurations*, **8**(3), 429-562. <https://doi.org/10.1353/con.2000.0019>.
- Habibi, M., Hashemi, R., Sadeghi, E., Fazaeli, A., Ghazanfari, A. and Lashini, H. (2016), "Enhancing the mechanical properties and formability of low carbon steel with dual-phase microstructures", *J. Mater. Eng. Perform.*, **25**(2), 382-389. <https://doi.org/10.1007/s11665-016-1882-1>.
- Habibi, M., Hashemi, R., Ghazanfari, A., Naghdabadi, R. and Assempour, A. (2018), "Forming limit diagrams by including the M-K model in finite element simulation considering the effect of bending", *Proceedings of the Institution of Mechanical Engineers, Part L: Journal of Materials: Design and Applications*, **232**(8), 625-636. <https://doi.org/10.1177/1464420716642258>.
- Hamidian, M., Shariati, M., Arabnejad, M. and Sinaei, H. (2011), "Assessment of high strength and light weight aggregate concrete properties using ultrasonic pulse velocity technique", *Int. J. Phys. Sci.*, **6**(22), 5261-5266. <https://doi.org/10.5897/IJPS11.1081>.
- Han, M., Hua, W., Xu, W. and Gong, Y. (2002), "An integrated baseball digest system using maximum entropy method", *Proceedings of the 10th ACM International Conference on Multimedia*, Juan-les-Pins, France, December.
- Hashemi, H.R., Alizadeh, A., Oyarhossein, M.A., Shavalipour, A., Makkiabadi, M. and Habibi, M. (2019), "Influence of imperfection on amplitude and resonance frequency of a reinforcement compositionally graded nanostructure", *Wave. Random Complex.*, 1-27. <https://doi.org/10.1080/17455030.2019.1662968>.
- Hausdorff, J.M., Purdon, P.L., Peng, C.-K., Ladin, Z., Wei, J.Y. and Goldberger, A.L. (1996), "Fractal dynamics of human gait: stability of long-range correlations in stride interval fluctuations", *J. Appl. Phys.*, **80**(5), 1448-1457. <https://doi.org/10.1152/jappl.1996.80.5.1448>.
- He, L., Chen, Y., Zhao, H., Tian, P., Xue, Y. and Chen, L. (2018), "Game-based analysis of energy-water nexus for identifying environmental impacts during Shale gas operations under stochastic input", *Sci. Total Environ.*, **627**, 1585-1601. <https://doi.org/10.1016/j.scitotenv.2018.02.004>.
- He, S., Guo, F. and Zou, Q. (2020), "MRMD2. 0: A python tool for machine learning with feature ranking and reduction", *Curr. Bioinform.*, **15**(10), 1213-1221. <https://doi.org/10.2174/1574893615999200503030350>.
- He, L., Shao, F. and Ren, L. (2021a), "Sustainability appraisal of desired contaminated groundwater remediation strategies: an information-entropy-based stochastic multi-criteria preference model", *Environ. Develop. Sust.*, **23**(2), 1759-1779. <https://doi.org/10.1007/s10668-020-00650-z>.
- He, X., Ding, J., Habibi, M., Safarpour, H. and Safarpour, M. (2021b), "Non-polynomial framework for bending responses of the multi-scale hybrid laminated nanocomposite reinforced circular/annular plate", *Thin Wall. Struct.*, **166**, 108019. <https://doi.org/10.1016/j.tws.2021.108019>.
- Heydari, A. and Shariati, M. (2018), "Buckling analysis of tapered BDFGM nano-beam under variable axial compression resting on elastic medium", *Struct. Eng. Mech.*, **66**(6), 737-748. <https://doi.org/10.12989/sem.2018.66.6.737>.
- Hong, Y. and Bartlett, R. (2008), *Routledge Handbook of Biomechanics and Human Movement Science*, Routledge, London, U.K.
- Hosseini, S., Habibi, M. and Assempour, A. (2018), "Experimental and numerical determination of forming limit diagram of steel-copper two-layer sheet considering the interface between the layers", *Modares Mech. Eng.*, **18**(6), 174-181.
- Hosseini, S.A. and Toghrol, A. (2021), "Effect of mixing Nano-silica and Perlite with pervious concrete for nitrate removal from the contaminated water", *Adv. Concrete Constr.*, **11**(6), 531-544. <https://doi.org/10.12989/acc.2021.11.6.531>.
- Hou, F.X., Wu, S.B., Moradi, Z. and Shafiei, N. (2021), "The computational modeling for the static analysis of axially functionally graded micro-cylindrical imperfect beam applying the computer simulation", *Eng. Comput.*, 1-19. <https://doi.org/10.1007/s00366-021-01456-x>.
- Huang, X., Hao, H., Oslub, K., Habibi, M. and Tounsi, A. (2021a), "Dynamic stability/instability simulation of the rotary size-dependent functionally graded microsystem", *Eng. Comput.*, 1-17. <https://doi.org/10.1007/s00366-021-01399-3>.
- Huang, X.P., Zhang, Y.M., Moradi, Z. and Shafiei, N. (2021b), "Computer simulation via a couple of homotopy perturbation methods and the generalized differential quadrature method for nonlinear vibration of functionally graded non-uniform micro-tube", *Eng. Comput.*, 1-18. <https://doi.org/10.1007/s00366-021-01395-7>.
- Huang, X.P., Zhu, Y.F., Vafaei, P., Moradi, Z. and Davoudi, M. (2021c), "An iterative simulation algorithm for large oscillation of the applicable 2D-electrical system on a complex nonlinear substrate", *Eng. Comput.*, 1-13. <https://doi.org/10.1007/s00366-021-01320-y>.
- Huang, Y., Wang, J., Wang, F. and He, B. (2021d), "Event-triggered adaptive finite-time tracking control for full state constraints nonlinear systems with parameter uncertainties and given transient performance", *ISA Transact.*, **108**, 131-143. <https://doi.org/10.1016/j.isatra.2020.08.022>.
- Huo, J., Zhang, G., Ghabussi, A. and Habibi, M. (2021), "Bending analysis of FG-GPLRC axisymmetric circular/annular sector plates by considering elastic foundation and horizontal friction force using 3D-poroelasticity theory", *Compos. Struct.*, **276**, 114438. <https://doi.org/10.1016/j.compstruct.2021.114438>.
- Intille, S.S., Davis, J.W. and Bobick, A.F. (1997), "Real-time closed-world tracking", *Proceedings of IEEE Computer Society Conference on Computer Vision and Pattern Recognition*, Puerto Rico, U.S.A., June.
- Ishii, I. and Ishikawa, M. (1999), "Self-windowing for high speed vision", *Proceedings 1999 IEEE International Conference on Robotics and Automation (Cat. No. 99CH36288C)*, Michigan, U.S.A., August.
- Ishikawa, M. (1998), "Super-parallel super-high-speed visual information system: General-purpose vision chip and grayscale photoelectron vision system", *Proceedings of Applied Physics*, **67**, 33-38.
- Jiang, Q., Shao, F., Gao, W., Chen, Z., Jiang, G. and Ho, Y.-S. (2018), "Unified no-reference quality assessment of singly and multiply distorted stereoscopic images", *IEEE T. Image Proc.*, **28**(4), 1866-1881. <https://doi.org/10.1109/TIP.2018.2881828>.
- Jiao, J., Ghoreishi, S.M., Moradi, Z. and Oslub, K. (2021), "Coupled particle swarm optimization method with genetic algorithm for the static-dynamic performance of the magneto-electro-elastic nanosystem", *Eng. Comput.*, 1-15. <https://doi.org/10.1007/s00366-021-01391-x>.
- Junkun, Y., Wenqiang, P., Shenghua, Z., Hongwei, L. and Greco, M.S. (2020), "Optimal resource allocation for asynchronous multiple target tracking in heterogeneous radar network", *IEEE T. Signal Proc.*, **68**, 4055-4068. <https://doi.org/10.1109/TSP.2020.3007313>.
- Katebi, J., Shoaei-parchin, M., Shariati, M., Trung, N.T. and Khorami, M. (2019), "Developed comparative analysis of metaheuristic optimization algorithms for optimal active control of structures", *Eng. Comput.*, 1-20. <https://doi.org/10.1007/s00366-019-00780-7>.
- Khorrarnian, K., Maleki, S., Shariati, M., Jalali, A. and Tahir,

- M.M. (2017), "Numerical analysis of tilted angle shear connectors in steel-concrete composite systems", *Steel Compos. Struct.*, **23**(1), 67-85. <https://doi.org/10.12989/scs.2017.23.1.067>.
- Kordestani, H. and Zhang, C. (2020), "Direct use of the savitzky-golay filter to develop an output-only trend line-based damage detection method", *Sensors*, **20**(7), 1983. <https://doi.org/10.3390/s20071983>.
- Kordestani, H., Zhang, C. and Shadabfar, M. (2020), "Beam damage detection under a moving load using random decrement technique and Savitzky-Golay Filter", *Sensors*, **20**(1), 243. <https://doi.org/10.3390/s20010243>.
- Kudo, K. and Ohtsuki, T. (2008), "Adaptive variability in skilled human movements", *Transact. Japan Soc. Artif. Intell.*, **23**(3), 151-162. <https://doi.org/10.1527/tjsai.23.151>.
- Lam, M., Chan, M., Leung, J., Wong, R., Hang, C. and Jin, J. (2003), "Computer-assisted off-side detection in soccer matches", *Proceedings of Technical Report, School of Information Technologies, University of Sydney*, Sydney, Australia.
- Li, D.Y., Toghroli, A., Shariati, M., Sajedi, F., Bui, D.T., Kianmehr, P., Mohamad, E.T. and Khorami, M. (2019a), "Application of polymer, silica-fume and crushed rubber in the production of Pervious concrete", *Smart Struct Syst.* **23**(2), 207-214. <https://doi.org/10.12989/sss.2019.23.2.207>.
- Li, X., Feng, Y., Liu, B., Yi, D., Yang, X., Zhang, W., Chen, G., Liu, Y. and Bai, P. (2019b), "Influence of NbC particles on microstructure and mechanical properties of AlCoCrFeNi high-entropy alloy coatings prepared by laser cladding", *J. Alloy. Compd.*, **788** 485-494. <https://doi.org/10.1016/j.jallcom.2019.02.223>.
- Li, B.H., Liu, Y., Zhang, A.M., Wang, W.H. and Wan, S. (2020a), "A survey on blocking technology of entity resolution", *J. Comput. Sci. Technol.*, **35**(4), 769-793. <https://doi.org/10.1007/s11390-020-0350-4>.
- Li, Y., Li, S., Guo, K., Fang, X. and Habibi, M. (2020b), "On the modeling of bending responses of graphene-reinforced higher order annular plate via two-dimensional continuum mechanics approach", *Eng. Comput.*, 1-22. <https://doi.org/10.1007/s00366-020-01166-w>.
- Li, B., Yang, J., Yang, Y., Li, C. and Zhang, Y. (2021), "Sign language/gesture recognition based on cumulative distribution density features using UWB radar", *IEEE T. Instrum. Meas.*, **70** 1-13. <https://doi.org/10.1109/TIM.2021.3092072>.
- Liu, T., Zhang, H.J. and Qi, F. (2003), "A novel video key-frame-extraction algorithm based on perceived motion energy model", *IEEE T. Circ. Syst. Vid.*, **13**(10), 1006-1013. <https://doi.org/10.1109/TCSVT.2003.816521>.
- Liu, S., Chan, F.T. and Ran, W. (2016), "Decision making for the selection of cloud vendor: An improved approach under group decision-making with integrated weights and objective/subjective attributes", *Expert Syst. Appl.*, **55**, 37-47. <https://doi.org/10.1016/j.eswa.2016.01.059>.
- Liu, L. and Liu, S. (2020), "Integrated production and distribution problem of perishable products with a minimum total order weighted delivery time", *Mathematics*, **8**(2), 146. <https://doi.org/10.3390/math8020146>.
- Liu, Q., Song, Z., Han, H., Donkor, S., Jiang, L., Wang, W. and Chu, H. (2020a), "A novel green reinforcement corrosion inhibitor extracted from waste *Platanus acerifolia* leaves", *Constr. Build. Mater.*, **260**, 119695. <https://doi.org/10.1016/j.conbuildmat.2020.119695>.
- Liu, S., Yu, W., Chan, F.T. and Niu, B. (2020b), "A variable weight-based hybrid approach for multi-attribute group decision making under interval-valued intuitionistic fuzzy sets", *Int. J. Intell. Syst.*, **36**(2), 1015-1052. <https://doi.org/10.1002/int.22329>.
- Liu, Z., Su, S.L., Xi, D.R. and Habibi, M. (2020c), "Vibrational responses of a MHC viscoelastic thick annular plate in thermal environment using GDQ method", *Mech. Based Des. Struct.*, 1-26. <https://doi.org/10.1080/15397734.2020.1784201>.
- Liu, Z.F., Wu, X.Y., Yu, M. and Habibi, M. (2020d), "Large-amplitude dynamical behavior of multilayer graphene platelets reinforced nanocomposite annular plate under thermo-mechanical loadings", *Mech. Based Des. Struct.*, 1-25. <https://doi.org/10.1080/15397734.2020.1815544>.
- Liu, C., Wang, F., Deng, X., Pang, S., Liu, J., Wu, Y. and Xu, Z. (2021a), "Hailstone-induced dynamic responses of pretensioned umbrella membrane structure", *Adv. Struct. Eng.*, **24**(1), 3-16. <https://doi.org/10.1177/1369433220940149>.
- Liu, F., Zhang, G. and Lu, J. (2021b), "Multisource heterogeneous unsupervised domain adaptation via fuzzy relation neural networks", *IEEE T. Fuzzy Syst.*, **29**(11), 3308-3322. <https://doi.org/10.1109/TFUZZ.2020.3018191>.
- Liu, H., Shen, S., Oslub, K., Habibi, M. and Safarpour, H. (2021c), "Amplitude motion and frequency simulation of a composite viscoelastic microsystem within modified couple stress elasticity", *Eng. Comput.*, 1-15. <https://doi.org/10.1007/s00366-021-01316-8>.
- Liu, H., Zhao, Y., Pishbin, M., Habibi, M., Bashir, M.O. and Issakhov, A. (2021d), "A comprehensive mathematical simulation of the composite size-dependent rotary 3D microsystem via two-dimensional generalized differential quadrature method", *Eng. Comput.*, 1-16. <https://doi.org/10.1007/s00366-021-01419-2>.
- Liu, R., Wang, X., Lu, H., Wu, Z., Fan, Q., Li, S. and Jin, X. (2021e), "SCCGAN: Style and characters inpainting based on CGAN", *Mobile Netw. Appl.*, **26**(1), 3-12. <https://doi.org/10.1007/s11036-020-01717-x>.
- Liu, Y., Wang, W.Q., He, T., Moradi, Z. and Benitez, M.L.A. (2021f), "On the modelling of the vibration behaviors via discrete singular convolution method for a high-order sector annular system", *Eng. Comput.*, 1-23. <https://doi.org/10.1007/s00366-021-01454-z>.
- Long, Q., Wu, C. and Wang, X. (2015), "A system of nonsmooth equations solver based upon subgradient method", *Appl. Math. Comput.*, **251**, 284-299. <https://doi.org/10.1016/j.amc.2014.11.064>.
- Lucas, B.D. and Kanade, T. (1981), "An iterative image registration technique with an application to stereo vision", *Proceedings of the 7th Conference on Artificial Intelligence*, Vancouver, Canadian August.
- Lv, X., Li, N., Xu, X. and Yang, Y. (2020), "Understanding the emergence and development of online travel agencies: A dynamic evaluation and simulation approach", *Internet Res.*, **30**(6), 1783-1810. <https://doi.org/10.1108/INTR-11-2019-0464>.
- Lv, Z. and Qiao, L. (2020), "Deep belief network and linear perceptron based cognitive computing for collaborative robots", *Appl. Soft Comput.*, **92**, 106300. <https://doi.org/10.1016/j.asoc.2020.106300>.
- Lv, Z., Qiao, L., Singh, A.K. and Wang, Q. (2021), "Fine-grained visual computing based on deep learning", **17**(1s), 1-19. <https://doi.org/10.1145/3418215>.
- Ma, H.J. and Xu, L.X. (2020), "Decentralized adaptive fault-tolerant control for a class of strong interconnected nonlinear systems via graph theory", *IEEE T. Autom. Contr.*, **66**(7), 3227-3234. <https://doi.org/10.1109/TAC.2020.3014292>.
- Ma, H.J., Yang, G.H. and Chen, T. (2020), "Event-triggered optimal dynamic formation of heterogeneous affine nonlinear multi-agent systems", *IEEE T. Autom. Contr.*, **66**(2), 497-512. <https://doi.org/10.1109/TAC.2020.2983108>.
- Ma, L.H., Liu, X.L. and Moradi, Z. (2021), "On the chaotic behavior of graphene-reinforced annular systems under harmonic excitation", *Eng. Comput.*, 1-25. <https://doi.org/10.1007/s00366-020-01210-9>.

- Mansouri, I., Safa, M., Ibrahim, Z., Kisi, O., Tahir, M.M., Baharom, S. and Azimi, M. (2016), "Strength prediction of rotary brace damper using MLR and MARS", *Struct. Eng Mech.* **60**(3), 471-488. <https://doi.org/10.12989/sem.2016.60.3.471>.
- Mehrabi, P., Shariati, M., Kabirifar, K., Jarrah, M., Rasekh, H., Trung, N.T., Shariati, A. and Jahandari, S. (2021), "Effect of pumice powder and nano-clay on the strength and permeability of fiber-reinforced pervious concrete incorporating recycled concrete aggregate", *Constr. Build. Mater.*, **287**, 122652. <https://doi.org/10.1016/j.conbuildmat.2021.122652>.
- Mi, C., Cao, L., Zhang, Z., Feng, Y., Yao, L. and Wu, Y. (2020), "A port container code recognition algorithm under natural conditions", *J. Coastal Res.*, **103**(SI), 822-829. <https://doi.org/10.2112/SI103-170.1>.
- Milovancevic, M., Marinovic, J.S., Nikolic, J., Kitic, A., Shariati, M., Trung, N.T., Wakil, K. and Khorami, M. (2019), "UML diagrams for dynamical monitoring of rail vehicles", *Physica A*, **531**, 121169. <https://doi.org/10.1016/j.physa.2019.121169>.
- Mirjavadi, S.S., Afshari, B.M., Shafiei, N., Hamouda, A., Kazemi, M. and Structures, C. (2017a), "Thermal vibration of two-dimensional functionally graded (2D-FG) porous Timoshenko nanobeams", *Steel Compos. Struct.*, **25**(4), 415-426. <https://doi.org/10.12989/scs.2017.25.4.415>.
- Mirjavadi, S.S., Matin, A., Shafiei, N., Rabby, S. and Mohasel Afshari, B. (2017b), "Thermal buckling behavior of two-dimensional imperfect functionally graded microscale-tapered porous beam", *J. Therm. Stress.*, **40**(10), 1201-1214. <https://doi.org/10.1080/01495739.2017.1332962>.
- Mirjavadi, S.S., Mohasel Afshari, B., Shafiei, N., Rabby, S. and Kazemi, M. (2017c), "Effect of temperature and porosity on the vibration behavior of two-dimensional functionally graded micro-scale Timoshenko beam", *J. Vib. Control.*, **24**(18), 4211-4225. <https://doi.org/10.1177/1077546317721871>.
- Mirjavadi, S.S., Rabby, S., Shafiei, N., Afshari, B.M. and Kazemi, M. (2017d), "On size-dependent free vibration and thermal buckling of axially functionally graded nanobeams in thermal environment", *Appl. Phys. A*, **123**(5), 315. <https://doi.org/10.1007/s00339-017-0918-1>.
- Moayedi, H., Aliakbarlou, H., Jebeli, M., Noormohammadiarani, O., Habibi, M., Safarpour, H. and Foong, L. (2020a), "Thermal buckling responses of a graphene reinforced composite micropanel structure", *Int. J. Appl. Mech.*, **12**(01), 20500106. <https://doi.org/10.1142/S1758825120500106>.
- Moayedi, H., Darabi, R., Ghabussi, A., Habibi, M. and Foong, L.K. (2020b), "Weld orientation effects on the formability of tailor welded thin steel sheets", *Thin Wall. Struct.*, **149**, 106669. <https://doi.org/10.1016/j.tws.2020.106669>.
- Mohammadhassani, M., Nezamabadi-Pour, H., Suhatri, M. and Shariati, M. (2013a), "Identification of a suitable ANN architecture in predicting strain in tie section of concrete deep beams", *Struct. Eng. Mech.*, **46**(6), 853-868. <https://doi.org/10.12989/sem.2013.46.6.853>.
- Mohammadhassani, M., Suhatri, M., Shariati, M. and Ghanbari, F. (2013b), "Ductility and strength assessment of HSC beams with varying of tensile reinforcement ratios", *Struct. Eng. Mech.*, **48**(6), 833-848. <https://doi.org/10.12989/sem.2013.48.6.833>.
- Mohammadhassani, M., Nezamabadi-pour, H., Suhatri, M. and Shariati, M. (2014), "An evolutionary fuzzy modelling approach and comparison of different methods for shear strength prediction of high-strength concrete beams without stirrups", *Smart Struct. Syst.*, **14**(5), 785-809. <https://doi.org/10.12989/sss.2014.14.5.785>.
- Mojtaba, D. (2011), "A new finite element investigation on pre-bent steel strips as damper for vibration control", *Int. J. Phys. Sci.*, **6**(36), 8044-8050. <https://doi.org/10.5897/ijps11.1585>.
- Najaafi, N., Jamali, M., Habibi, M., Sadeghi, S., Jung, D.W. and Nabipour, N. (2021), "Dynamic instability responses of the substructure living biological cells in the cytoplasm environment using stress-strain size-dependent theory", *J. Biomol. Struct. Dyn.*, **39**(7), 2543-2554. <https://doi.org/10.1080/07391102.2020.1751297>.
- Ni, T., Chang, H., Song, T., Xu, Q., Huang, Z., Liang, H., Yan, A. and Wen, X. (2019a), "Non-intrusive online distributed pulse shrinking-based interconnect testing in 2.5 D IC", *IEEE T. Circ. Syst II*, **67**(11), 2657-2661. <https://doi.org/10.1109/TCSII.2019.2962824>.
- Ni, T., Yao, Y., Chang, H., Lu, L., Liang, H., Yan, A., Huang, Z. and Wen, X. (2019b), "LCHR-TSV: Novel low cost and highly repairable honeycomb-based TSV redundancy architecture for clustered faults", *IEEE T. Comput. Aid. D.*, **39**(10), 2938-2951. <https://doi.org/10.1109/TCAD.2019.2946243>.
- Niu, Z., Zhang, B., Wang, J., Liu, K., Chen, Z., Yang, K., Zhou, Z., Fan, Y., Zhang, Y. and Ji, D. (2020), "The research on 220GHz multicarrier high-speed communication system", *China Commun.*, **17**(3), 131-139. <https://doi.org/10.23919/JCC.2020.03.011>.
- Nosrati, A., Zandi, Y., Shariati, M., Khademi, K., Aliabad, M.D., Marto, A., Mu'azu, M., Ghanbari, E., Mandizadeh, M.B., Shariati, A. and Khorami, M. (2018), "Portland cement structure and its major oxides and fineness", *Smart Struct. Syst.*, **22**(4), 425-432. <https://doi.org/10.12989/sss.2018.22.4.425>.
- Oyarhossein, M.A., Alizadeh, A.A., Habibi, M., Makkiabadi, M., Daman, M., Safarpour, H. and Jung, D.W. (2020), "Dynamic response of the nonlocal strain-stress gradient in laminated polymer composites microtubes", *Sci. Rep.*, **10**(1), 1-19. <https://doi.org/10.1038/s41598-020-61855-w>.
- Pan, D., Xia, X.X., Zhou, H., Jin, S.Q., Lu, Y.Y., Liu, H., Gao, M.L. and Jin, Z.B. (2020), "COCO enhances the efficiency of photoreceptor precursor differentiation in early human embryonic stem cell-derived retinal organoids", *Stem Cell Res. Therapy*, **11**(1), 1-12. <https://doi.org/10.1186/s13287-020-01883-5>.
- Peng, D.P., Chen, S., Darabi, R., Ghabussi, A. and Habibi, M. (2021), "Prediction of the bending and out-of-plane loading effects on formability response of the steel sheets", *Arch. Civil Mech. Eng.*, **21**(2), 1-13. <https://doi.org/10.1007/s43452-021-00227-1>.
- Pingali, G., Opalach, A. and Jean, Y. (2000), "Ball tracking and virtual replays for innovative tennis broadcasts", *Proceedings 15th International Conference on Pattern Recognition, ICPR-2000*, Barcelona, Spain, August.
- Post, A., Daffertshofer, A. and Beek, P.J. (2000), "Principal components in three-ball cascade juggling", *Biol. Cybernet.*, **82**(2), 143-152. <https://doi.org/10.1007/PL00007966>.
- Ran, W., Liu, S. and Zhang, Z. (2020), "A polling-based dynamic order-picking system considering priority orders", *Complexity*, **2020**. <https://doi.org/10.1155/2020/4595316>.
- Reid, M., Morgan, S. and Whiteside, D. (2016), "Matchplay characteristics of Grand Slam tennis: Implications for training and conditioning", *J. Sport Sci.*, **34**(19), 1791-1798. <https://doi.org/10.1080/02640414.2016.1139161>.
- Sadeghipour Chahnasir, E., Zandi, Y., Shariati, M., Deghani, E., Toghroli, A., Mohamed, E.T., Shariati, A., Safa, M., Wakil, K. and Khorami, M. (2018), "Application of support vector machine with firefly algorithm for investigation of the factors affecting the shear strength of angle shear connectors", *Smart Struct. Syst.*, **22**(4), 413-424. <http://doi.org/10.12989/sss.2018.22.4.413>.
- Safa, M., Shariati, M., Ibrahim, Z., Toghroli, A., Bin Baharom, S., Nor, N.M. and Petkovic, D. (2016), "Potential of adaptive neuro fuzzy inference system for evaluating the factors affecting steel-concrete composite beam's shear strength", *Steel Compos. Struct.*, **21**(3), 679-688.

- <https://doi.org/10.12989/scs.2016.21.3.679>.
- Safa, M., Sari, P.A., Shariati, M., Suhatri, M., Trung, N.T., Wakil, K. and Khorami, M. (2020), "Development of neuro-fuzzy and neuro-bee predictive models for prediction of the safety factor of eco-protection slopes", *Physica A*, **550**, 124046. <https://doi.org/10.1016/j.physa.2019.124046>.
- Sajedi, F. and Shariati, M. (2019), "Behavior study of NC and HSC RCCs confined by GRP casing and CFRP wrapping", *Steel Compos. Struct.*, **30**(5), 417-432. <https://doi.org/10.12989/scs.2019.30.5.417>.
- Sedghi, Y., Zandi, Y., Shariati, M., Ahmadi, E., Azar, V.M., Togholi, A., Safa, M., Mohamad, E.T., Khorami, M. and Wakil, K. (2018), "Application of ANFIS technique on performance of C and L shaped angle shear connectors", *Smart Struct. Syst.*, **22**(3), 335-340. <https://doi.org/10.12989/sss.2018.22.3.335>.
- Shafiei, N., Kazemi, M. and Ghadiri, M. (2016a), "Comparison of modeling of the rotating tapered axially functionally graded Timoshenko and Euler-Bernoulli microbeams", *Physica E*, **83**, 74-87. <https://doi.org/10.1016/j.physe.2016.04.011>.
- Shafiei, N., Kazemi, M. and Ghadiri, M. (2016b), "Nonlinear vibration behavior of a rotating nanobeam under thermal stress using Eringen's nonlocal elasticity and DQM", *Appl. Phys A*, **122**(8), 728. <https://doi.org/10.1007/s00339-016-0245-y>.
- Shafiei, N., Kazemi, M. and Ghadiri, M. (2016c), "Nonlinear vibration of axially functionally graded tapered microbeams", *Int. J. Eng. Sci.*, **102**, 12-26. <https://doi.org/10.1016/j.ijengsci.2016.02.007>.
- Shafiei, N., Kazemi, M. and Ghadiri, M. (2016d), "On size-dependent vibration of rotary axially functionally graded microbeam", *Int. J. Eng. Sci.*, **101**, 29-44. <https://doi.org/10.1016/j.ijengsci.2015.12.008>.
- Shafiei, N., Kazemi, M., Safi, M. and Ghadiri, M. (2016e), "Nonlinear vibration of axially functionally graded non-uniform nanobeams", *Int. J. Eng. Sci.*, **106**, 77-94. <https://doi.org/10.1016/j.ijengsci.2016.05.009>.
- Shafiei, N., Mousavi, A. and Ghadiri, M. (2016f), "On size-dependent nonlinear vibration of porous and imperfect functionally graded tapered microbeams", *Int. J. Eng. Sci.*, **106**, 42-56. <https://doi.org/10.1016/j.ijengsci.2016.05.007>.
- Shafiei, N., Mousavi, A. and Ghadiri, M. (2016g), "Vibration behavior of a rotating non-uniform FG microbeam based on the modified couple stress theory and GDQEM", *Compos. Struct.*, **149**, 157-169. <https://doi.org/10.1016/j.compstruct.2016.04.024>.
- Shafiei, N., Ghadiri, M., Makvandi, H. and Hosseini, S.A. (2017a), "Vibration analysis of Nano-Rotor's Blade applying Eringen nonlocal elasticity and generalized differential quadrature method", *Appl. Math. Model.*, **43**, 191-206. <https://doi.org/10.1016/j.apm.2016.10.061>.
- Shafiei, N., Kazemi, M. and Fatahi, L. (2017b), "Transverse vibration of rotary tapered microbeam based on modified couple stress theory and generalized differential quadrature element method", *Mech. Adv. Mater. Struct.*, **24**(3), 240-252. <https://doi.org/10.1080/15376494.2015.1128025>.
- Shafiei, N., Mirjavadi, S.S., Afshari, B.M., Rabby, S. and Hamouda, A.M.S. (2017c), "Nonlinear thermal buckling of axially functionally graded micro and nanobeams", *Compos. Struct.*, **168**, 428-439. <https://doi.org/10.1016/j.compstruct.2017.02.048>.
- Shafiei, N., Mirjavadi, S.S., MohaselAfshari, B., Rabby, S. and Kazemi, M. (2017d), "Vibration of two-dimensional imperfect functionally graded (2D-FG) porous nano-/micro-beams", *Computer Methods Appl. M.*, **322**, 615-632. <https://doi.org/10.1016/j.cma.2017.05.007>.
- Shafiei, N. and Kazemi, M. (2017a), "Buckling analysis on the bi-dimensional functionally graded porous tapered nano-/micro-scale beams", *Aerosp. Sci. Technol.*, **66**, 1-11. <https://doi.org/10.1016/j.ast.2017.02.019>.
- Shafiei, N. and Kazemi, M. (2017b), "Nonlinear buckling of functionally graded nano-/micro-scaled porous beams", *Compos. Struct.*, **178**, 483-492. <https://doi.org/10.1016/j.compstruct.2017.07.045>.
- Shafiei, N. and She, G.L. (2018), "On vibration of functionally graded nano-tubes in the thermal environment", *Int. J. Eng. Sci.*, **133**, 84-98. <https://doi.org/10.1016/j.ijengsci.2018.08.004>.
- Shafiei, N., Ghadiri, M. and Mahinzare, M. (2019), "Flapwise bending vibration analysis of rotary tapered functionally graded nanobeam in thermal environment", *Mech. Adv. Mater. Struct.*, **26**(2), 139-155. <https://doi.org/10.1080/15376494.2017.1365982>.
- Shafiei, N., Hamisi, M. and Ghadiri, M. (2020), "Vibration analysis of rotary tapered axially functionally graded Timoshenko nanobeam in thermal environment", *J. Solid Mech.*, **12**(1), 16-32. <https://doi.org/10.22034/JSM.2019.563759.12>.
- Shahabi, S.E.M., Sulong, N.H.R., Shariati, M., Mohammadhassani, M. and Shah, S.N.R. (2016), "Numerical analysis of channel connectors under fire and a comparison of performance with different types of shear connectors subjected to fire", *Steel Compos. Struct.*, **20**(3), 651-669. <https://doi.org/10.12989/scs.2016.20.3.651>.
- Shao, Y.H., Zhao, Y., Gao, J. and Habibi, M. (2021), "Energy absorption of the strengthened viscoelastic multi-curved composite panel under friction force", *Arch. Civil Mech. Eng.*, **21**(4), 1-29. <https://doi.org/10.1007/s43452-021-00279-3>.
- Shariati, M., Ramli Sulong, N.H., Arabnejad Khanouki, M.M. and Shariati, A. (2011a), "Experimental and numerical investigations of channel shear connectors in high strength concrete", *Proceedings of the 2011 World Congress on Advances in Structural Engineering and Mechanics (ASEM'11+)*, Seoul, South Korea, September.
- Shariati, M., Ramli Sulong, N.H., Sinaei, H., Arabnejad Khanouki, M.M. and Shafiq, P. (2011b), "Behavior of channel shear connectors in normal and light weight aggregate concrete (Experimental and analytical study)", *Adv. Mater. Res.*, **168**, 2303-2307. <https://doi.org/10.4028/www.scientific.net/AMR.168-170.2303>.
- Shariati, M. (2008), "Assessment building using non-destructive test techniques (ultra sonic pulse velocity and schmidt rebound hammer)", Ph.D. Dissertation, Universiti Putra Malaysia, Selangor, Malaysia.
- Shariati, M., Faegh, S.S., Mehrabi, P., Bahavarnia, S., Zandi, Y., Masoom, D.R., Togholi, A., Trung, N.T. and Salih, M.N.A. (2019a), "Numerical study on the structural performance of corrugated low yield point steel plate shear walls with circular openings", *Steel Compos. Struct.*, **33**(4), 569-581. <https://doi.org/10.12989/scs.2019.33.4.569>.
- Shariati, M., Heyrati, A., Zandi, Y., Laka, H., Togholi, A., Kianmehr, P., Safa, M., Salih, M.N.A. and Poi-Ngian, S. (2019b), "Application of waste tire rubber aggregate in porous concrete", *Smart Struct. Syst.*, **24**(4), 553-566. <https://doi.org/10.12989/sss.2019.24.4.553>.
- Shariati, M., Mafipour, M.S., Mehrabi, P., Bahadori, A., Zandi, Y., Salih, M.N.A., Nguyen, H., Dou, J., Song, X. and Poi-Ngian, S. (2019c), "Application of a hybrid artificial neural network-particle swarm optimization (ANN-PSO) model in behavior prediction of channel shear connectors embedded in normal and high-strength concrete", *Appl. Sci.*, **9**(24), 5534. <https://doi.org/10.3390/app9245534>.
- Shariati, M., Mafipour, M.S., Mehrabi, P., Zandi, Y., Dehghani, D., Bahadori, A., Shariati, A., Trung, N.T., Salih, M.N.A. and Poi-Ngian, S. (2019d), "Application of Extreme Learning Machine (ELM) and Genetic Programming (GP) to design steel-concrete composite floor systems at elevated temperatures", *Steel Compos. Struct.*, **33**(3), 319-332.

- <https://doi.org/10.12989/scs.2019.33.3.319>.
- Shariati, M., Rafie, S., Zandi, Y., Fooladvand, R., Gharehaghaj, B., Mehrabi, P., Shariat, A., Trung, N.T., Salih, M.N.A. and Poinngian, S. (2019e), "Experimental investigation on the effect of cementitious materials on fresh and mechanical properties of self-consolidating concrete", *Adv. Concr. Constr.*, **8**(3), 225-237. <https://doi.org/10.12989/acc.2019.8.3.225>.
- Shariati, M., Trung, N.T., Wakil, K., Mehrabi, P., Safa, M. and Khorami, M. (2019f), "Moment-rotation estimation of steel rack connection using extreme learning machine", *Steel Compos. Struct.*, **31**(5), 427-435. <https://doi.org/10.12989/scs.2019.31.5.427>.
- Shariati, A., Jung, D.W., Mohammad-Sedighi, H., Zur, K.K., Habibi, M. and Safa, M. (2020a), "On the vibrations and stability of moving viscoelastic axially functionally graded nanobeams", *Materials*, **13**(7), 1707. <https://doi.org/10.3390/ma13071707>.
- Shariati, A., Jung, D.W., Mohammad-Sedighi, H., Zur, K.K., Habibi, M. and Safa, M. (2020b), "Stability and dynamics of viscoelastic moving rayleigh beams with an asymmetrical distribution of material parameters", *Symmetry*, **12**(4), 586. <https://doi.org/10.3390/sym12040586>.
- Shariati, M., Mafipour, M.S., Ghahremani, B., Azarhomayun, F., Ahmadi, M., Trung, N.T. and Shariati, A. (2020c), "A novel hybrid extreme learning machine-grey wolf optimizer (ELM-GWO) model to predict compressive strength of concrete with partial replacements for cement", *Eng. Comput.*, 1-23. <https://doi.org/10.1007/s00366-020-01081-0>.
- Shariati, M., Mafipour, M.S., Haido, J.H., Yousif, S.T., Toghroli, A., Trung, N.T. and Shariati, A. (2020d), "Identification of the most influencing parameters on the properties of corroded concrete beams using an Adaptive Neuro-Fuzzy Inference System (ANFIS)", *Steel Compos. Struct.*, **34**(1), 155-170. <https://doi.org/10.12989/scs.2020.34.1.155>.
- Shariati, M., Mafipour, M.S., Mehrabi, P., Shariati, A., Toghroli, A., Trung, N.T. and Salih, M.N. (2020e), "A novel approach to predict shear strength of tilted angle connectors using artificial intelligence techniques", *Eng. Comput.*, 1-21. <https://doi.org/10.1007/s00366-019-00930-x>.
- Shariati, M., Naghipour, M., Yousofizinsaz, G., Toghroli, A. and Tabarestani, N.P. (2020f), "Numerical study on the axial compressive behavior of built-up CFT columns considering different welding lines", *Steel Compos. Struct.* **34**(3), 377-391. <https://doi.org/10.12989/scs.2020.34.3.377>.
- Shariati, A., Habibi, M., Tounsi, A., Safarpour, H. and Safa, M. (2021a), "Application of exact continuum size-dependent theory for stability and frequency analysis of a curved cantilevered microtubule by considering viscoelastic properties", *Eng. Comput.*, **37**(4), 3629-3648. <https://doi.org/10.1007/s00366-020-01024-9>.
- Shariati, M., Davoodnabi, S.M., Toghroli, A., Kong, Z.Y. and Shariati, A. (2021b), "Hybridization of metaheuristic algorithms with adaptive neuro-fuzzy inference system to predict load-slip behavior of angle shear connectors at elevated temperatures", *Compos. Struct.*, **278**, 114524. <https://doi.org/10.1016/j.compstruct.2021.114524>.
- Shi, K., Tang, Y., Liu, X. and Zhong, S. (2017), "Secondary delay-partition approach on robust performance analysis for uncertain time-varying Lurie nonlinear control system", *Opt. Contr. Appl. Method.*, **38**(6), 1208-1226. <https://doi.org/10.1002/oca.2326>.
- Shi, X.F., Li, J.Y. and Habibi, M. (2020), "On the statics and dynamics of an electro-thermo-mechanically porous GPLRC nanoshell conveying fluid flow", *Mech. Based Des. Struct.*, 1-37. <https://doi.org/10.1080/15397734.2020.1772088>.
- Shivanian, E., Ghadiri, M. and Shafiei, N. (2017), "Influence of size effect on flapwise vibration behavior of rotary microbeam and its analysis through spectral meshless radial point interpolation", *Appl. Phys. A*, **123**(5), 329. <https://doi.org/10.1007/s00339-017-0955-9>.
- Sinaei, H., Jumaat, M.Z. and Shariati, M. (2011), "Numerical investigation on exterior reinforced concrete Beam-Column joint strengthened by composite fiber reinforced polymer (CFRP)", *Int. J. Phys. Sci.*, **6**(28), 6572-6579. <https://doi.org/10.5897/IJPS11.1225>.
- Sinaei, H., Shariati, M., Abna, A.H., Aghaei, M. and Shariati, A. (2012), "Evaluation of reinforced concrete beam behaviour using finite element analysis by ABAQUS", *Sci. Res. Essays*, **7**(21), 2002-2009. <https://doi.org/10.5897/SRE11.1393>.
- Stergiou, N. (2004), *Innovative Analyses of Human Movement*, Human Kinetics Publishers, Illinois, Canada.
- Sudhir, G., Lee, J.C.M. and Jain, A.K. (1998), "Automatic classification of tennis video for high-level content-based retrieval", *Proceedings 1998 IEEE International Workshop on Content-Based Access of Image and Video Database*, Bombay, India, January.
- Sun, J., Du, H., Chen, Z., Wang, L. and Shen, G. (2021), "MXene quantum dot within natural 3D watermelon peel matrix for biocompatible flexible sensing platform", *Nano Res.*, 1-7. <https://doi.org/10.1007/s12274-021-3967-x>.
- Suthaharan, S., Kim, S.-W., Sathanathan, S., Lee, H.-K. and Rao, K. (1999), "Perceptually tuned video watermarking scheme using motion entropy masking", *Proceedings of IEEE. IEEE Region 10 Conference. TENCON 99. 'Multimedia Technology for Asia-Pacific Information Infrastructure' (Cat. No. 99CH37030)*, Jeju, Korea, September.
- Theobalt, C., Albrecht, I., Haber, J., Magnor, M. and Seidel, H.P. (2004), *Pitching a Baseball: Tracking High-Speed Motion with Multi-Exposure Images in ACM SIGGRAPH 2004 Papers*, Association for Computing Machinery, New York, U.S.A.
- Toghroli, A., Mohammadhassani, M., Suhatri, M., Shariati, M. and Ibrahim, Z. (2014), "Prediction of shear capacity of channel shear connectors using the ANFIS model", *Steel Compos. Struct.*, **17**(5), 623-639. <http://doi.org/10.12989/scs.2014.17.5.623>.
- Toghroli, A., Suhatri, M., Ibrahim, Z., Safa, M., Shariati, M. and Shamshirband, S. (2016), "Potential of soft computing approach for evaluating the factors affecting the capacity of steel-concrete composite beam", *J. Intell. Manuf.*, **29**(8), 1793-1801. <https://doi.org/10.1007/s10845-016-1217-y>.
- Toghroli, A., Shariati, M., Karim, M.R. and Ibrahim, Z. (2017), "Investigation on composite polymer and silica fume-rubber aggregate pervious concrete", *Proceedings of the 5th International Conference on Advances in Civil, Structural and Mechanical Engineering - CSM 2017*, Zurich, Switzerland, September.
- Toghroli, A., Shariati, M., Sajedi, F., Ibrahim, Z., Koting, S., Mohamad, E.T. and Khorami, M. (2018), "A review on pavement porous concrete using recycled waste materials", *Smart Struct. Syst.* **22**(4), 433-440. <https://doi.org/10.12989/sss.2018.22.4.433>.
- Trung, N.T., Alemi, N., Haido, J.H., Shariati, M., Baradaran, S. and Yousif, S.T. (2019), "Reduction of cement consumption by producing smart green concretes with natural zeolites", *Smart Struct. Syst.*, **24**(3), 415-425. <https://doi.org/10.12989/sss.2019.24.3.415>.
- Toghroli, A., Mehrabi, P., Shariati, M., Trung, N.T., Jahandari, S. and Rasekh, H. (2020), "Evaluating the use of recycled concrete aggregate and pozzolanic additives in fiber-reinforced pervious concrete with industrial and recycled fibers", *Constr. Build. Mater.*, **252**, 118997. <https://doi.org/10.1016/j.conbuildmat.2020.118997>.
- Wang, B., Zhang, B., Liu, X. and Zou, F. (2020a), "Novel infrared image enhancement optimization algorithm combined with

- DFOCS”, *Optik*, **224**, 165476.  
<https://doi.org/10.1016/j.ijleo.2020.165476>.
- Wang, J., Huang, Y., Wang, T., Zhang, C. and hui Liu, Y. (2020b), “Fuzzy finite-time stable compensation control for a building structural vibration system with actuator failures”, *Appl. Soft Comput.*, **93**, 106372.  
<https://doi.org/10.1016/j.asoc.2020.106372>.
- Wang, J., Zhu, P., He, B., Deng, G., Zhang, C. and Huang, X. (2020c), “An adaptive neural sliding mode control with ESO for uncertain nonlinear systems”, *Int. J. Control Autom.*, 1-11.  
<https://doi.org/10.1007/s12555-019-0972-x>.
- Wang, L., Huang, Y., Xie, Y. and Du, Y. (2020d), “A new regularization method for dynamic load identification”, *Sci. Progress*, **103**(3), 0036850420931283.  
<https://doi.org/10.1177/0036850420931283>.
- Wang, Z.Y., Yu, S.Q., Xiao, Z.X. and Habibi, M. (2020e), “Frequency and buckling responses of a high-speed rotating fiber metal laminated cantilevered microdisk”, *Mech. Adv. Mater. Struct.*, 1-14.  
<https://doi.org/10.1080/15376494.2020.1824284>.
- Wang, B., Zhang, B. and Liu, X. (2021), “An image encryption approach on the basis of a time delay chaotic system”, *Optik*, **225**, 165737. <https://doi.org/10.1016/j.ijleo.2020.165737>.
- Wu, J.H. and Habibi, M. (2021), “Dynamic simulation of the ultra-fast-rotating sandwich cantilever disk via finite element and semi-numerical methods”, *Eng. Comput.*, 1-17.  
<https://doi.org/10.1007/s00366-021-01396-6>.
- Wu, Z., Li, C., Cao, J. and Ge, Y. (2020), “On scalability of association-rule-based recommendation: A unified distributed-computing framework”, *ACM T. Web*, **14**(3), 1-15.  
<https://doi.org/10.1145/3398202>.
- Wu, X., Zheng, W., Xia, X. and Lo, D. (2021), “Data quality matters: a case study on data label correctness for security bug report prediction”, *IEEE T. Softw. Eng.*, 1-1.  
<https://doi.org/10.1109/TSE.2021.3063727>.
- Xiaolong, D., Bai, W., Bin, W. and Shengqi, Y. (2012), “Modularity modeling and evaluation in community detecting of complex network based on information entropy”, *J. Comput. Res. Develop.*, **49**(4), 725.
- Xie, J., Wen, D., Liang, L., Jia, Y., Gao, L. and Lei, J. (2018), “Evaluating the validity of current mainstream wearable devices in fitness tracking under various physical activities: Comparative study”, *JMIR mHealth uHealth*, **6**(4), e94.  
<https://doi.org/10.2196/mhealth.9754>.
- Xie, W., Zhang, R., Zeng, D., Shi, K. and Zhong, S. (2020), “Strictly dissipative stabilization of multiple-memory Markov jump systems with general transition rates: A novel event-triggered control strategy”, *Int. J. Robust Nonlin.*, **30**(5), 1956-1978. <https://doi.org/10.1002/rnc.4856>.
- Xu, L., Paila, T., Hansmann, W. and Frank, M. (2003), “Intel open source computer vision library, version 3.1”, *Proceedings of the 26th Annual Conference on Local Computer Networks, LCN'01*, Washington D.C., U.S.A. November.
- Xu, M., Li, C., Chen, Z., Wang, Z. and Guan, Z. (2018), “Assessing visual quality of omnidirectional videos”, *IEEE T. Circ. Syst. Vid.*, **29**(12), 3516-3530.  
<https://doi.org/10.1109/TCSVT.2018.2886277>.
- Xu, M., Li, C., Zhang, S. and Le Callet, P. (2020), “State-of-the-art in 360 video/image processing: Perception, assessment and compression”, *IEEE J. Sel. Top. Signal Proc.*, **14**(1), 5-26.  
<https://doi.org/10.1109/JSTSP.2020.2966864>.
- Xu, W.T., Pan, G.J., Moradi, Z. and Shafiei, N. (2021), “Nonlinear forced vibration analysis of functionally graded non-uniform cylindrical microbeams applying the semi-analytical solution”, *Compos. Struct.*, **275**, 114395.  
<https://doi.org/10.1016/j.compstruct.2021.114395>.
- Yang, M. and Sowmya, A. (2015), “An underwater color image quality evaluation metric”, *IEEE T. Image Proc.*, **24**(12), 6062-6071. <https://doi.org/10.1109/TIP.2015.2491020>.
- Yang, R., Xu, M., Liu, T., Wang, Z. and Guan, Z. (2018), “Enhancing quality for HEVC compressed videos”, *IEEE T. Circ. Syst. Vid.*, **29**(7), 2039-2054.  
<https://doi.org/10.1109/TCSVT.2018.2867568>.
- Yazdani, M., Kabirifar, K., Frimpong, B.E., Shariati, M., Mirmozaffari, M. and Boskabadi, A. (2020), “Improving construction and demolition waste collection service in an urban area using a simheuristic approach: A case study in Sydney, Australia”, *J. Clean. Prod.*, **280**, 124138.  
<https://doi.org/10.1016/j.jclepro.2020.124138>.
- Yow, D., Yeo, B.L., Yeung, M. and Liu, B. (1995), “Analysis and presentation of soccer highlights from digital video”, *Proceedings of the Second Asian Conference on Computer Vision (ACCV '95)*, Singapore, December.
- Yu, J., Fang, L., Cang, D., Zhu, L. and Bian, Z. (2012), “Evaluation of land eco-security in Wanjiang district base on entropy weight and matter element model”, *Transact. Chinese Soc. Agric. Eng.*, **28**(5), 260-266.
- Yu, X.M., Maalla, A. and Moradi, Z. (2022), “Electroelastic high-order computational continuum strategy for critical voltage and frequency of piezoelectric NEMS via modified multi-physical couple stress theory”, *Mech. Syst. Signal. Pr.*, **165**, 108373.  
<https://doi.org/10.1016/j.ymsp.2021.108373>.
- Yue, H., Wang, H., Chen, H., Cai, K. and Jin, Y. (2020), “Automatic detection of feather defects using lie group and fuzzy fisher criterion for shuttlecock production”, *Mech. Syst. Signal. Pr.*, **141**, 106690.  
<https://doi.org/10.1016/j.ymsp.2020.106690>.
- Zhang, C., Li, L. and Ou, J. (2010), “Swinging motion control of suspended structures: Principles and applications”, *Struct. Contr. Health Monit.*, **17**(5), 549-562.  
<https://doi.org/10.1002/stc.331>.
- Zhang, Z., Kong, L., Zheng, L., Zhang, P., Qu, X., Liao, B. and Yu, Z. (2018), “Robustness analysis of a power-type varying-parameter recurrent neural network for solving time-varying qm and qp problems and applications”, *IEEE T. Syst. Man Cy.*, **50**(12), 5106-5118.  
<https://doi.org/10.1109/TSMC.2018.2866843>.
- Zhang, H., Qiu, Z., Cao, J., Abdel-Aty, M. and Xiong, L. (2019), “Event-triggered synchronization for neutral-type semi-Markovian neural networks with partial mode-dependent time-varying delays”, *IEEE T Neural Networ.*, **31**(11), 4437-4450.  
<https://doi.org/10.1109/TNNLS.2019.2955287>.
- Zhang, L., Chen, Z.X., Habibi, M., Ghabussi, A. and Alyousef, R. (2021a), “Low-velocity impact, resonance, and frequency responses of FG-GPLRC viscoelastic doubly curved panel”, *Compos. Struct.*, **269**, 114000.  
<https://doi.org/10.1016/j.compstruct.2021.114000>.
- Zhang, X., Shamsodin, M., Wang, H., NoormohammadiArani, O., Khan, A.M., Habibi, M. and Al-Furjan, M. (2021b), “Dynamic information of the time-dependent tobullian biomolecular structure using a high-accuracy size-dependent theory”, *J. Biomol. Struct. Dyn.*, **39**(9), 3128-3143.  
<https://doi.org/10.1080/07391102.2020.1760939>.
- Zhang, Y., Wang, Z., Tazeddinova, D., Ebrahimi, F., Habibi, M. and Safarpour, H. (2021c), “Enhancing active vibration control performances in a smart rotary sandwich thick nanostructure conveying viscous fluid flow by a PD controller”, *Wave. Random Complex.*, 1-24.  
<https://doi.org/10.1080/17455030.2021.1948627>.
- Zhao, J., Liu, J., Jiang, J. and Gao, F. (2020), “Efficient deployment with geometric analysis for mmWave UAV communications”, *IEEE Wirel. Commun.*, **9**(7), 1115-1119.  
<https://doi.org/10.1109/LWC.2020.2982637>.
- Zhao, Y.N., Moradi, Z., Davoudi, M. and Zhuang, J.W. (2021),

- “Bending and stress responses of the hybrid axisymmetric system via state-space method and 3D-elasticity theory”, *Eng Comput.*, 1-23. <https://doi.org/10.1007/s00366-020-01242-1>.
- Zhiyong, L., Xiang, W. and Nan, Z. (2012), *An Evaluation Model for Synchronized Supply Chain Based on Entropy Weight and TOPSIS I*, Springer, Berlin, Germany.
- Zhong, D. and Chang, S.F. (1997), “Spatio-temporal video search using the object based video representation”, *Proceedings of International Conference on Image Processing*, California, U.S.A., August.
- Zhou, C.L., Zhao, Y., Zhang, J., Fang, Y. and Habibi, M. (2020), “Vibrational characteristics of multi-phase nanocomposite reinforced circular/annular system”, *Adv Nano Res.*, **9**(4), 295-307. <https://doi.org/10.12989/anr.2020.9.4.295>.
- Zhou, J. and Li, X.B. (2012), “Integrating unascertained measurement and information entropy theory to assess blastability of rock mass”, *J. Cent. South Univ.*, **19**(7), 1953-1960. <https://doi.org/10.1007/s11771-012-1231-y>.
- Zhou, W., Yu, L., Zhou, Y., Qiu, W., Wu, M.W. and Luo, T. (2018), “Local and global feature learning for blind quality evaluation of screen content and natural scene images”, *IEEE T. Image Proc.*, **27**(5), 2086-2095. <https://doi.org/10.1109/TIP.2018.2794207>.
- Zhu, L., Zhang, C., Guan, X., Uy, B., Sun, L. and Wang, B. (2018), “The multi-axial strength performance of composited structural BCW members subjected to shear forces”, *Steel Compos Struct.*, **27**(1), 75-87. <https://doi.org/10.12989/scs.2018.27.1.075>.
- Zhu, Q. (2019), “Research on road traffic situation awareness system based on image big data”, *IEEE Intell. Syst.*, **35**(1), 18-26. <https://doi.org/10.1109/MIS.2019.2942836>.
- Ziaei-Nia, A., Shariati, M. and Salehabadi, E. (2018), “Dynamic mix design optimization of high-performance concrete”, *Steel Compos Struct.*, **29**(1), 67-75. <https://doi.org/10.12989/scs.2018.29.1.067>.
- Zuo, C., Chen, Q., Gu, G., Feng, S., Feng, F., Li, R. and Shen, G. (2013), “High-speed three-dimensional shape measurement for dynamic scenes using bi-frequency tripolar pulse-width-modulation fringe projection”, *Opt. Laser Eng.*, **51**(8), 953-960. <https://doi.org/10.1016/j.optlaseng.2013.02.012>.
- Zuo, C., Chen, Q., Tian, L., Waller, L. and Asundi, A. (2015), “Transport of intensity phase retrieval and computational imaging for partially coherent fields: The phase space perspective”, *Opt. Laser Eng.*, **71**, 20-32. <https://doi.org/10.1016/j.optlaseng.2015.03.006>.
- Zuo, C., Sun, J., Li, J., Zhang, J., Asundi, A. and Chen, Q. (2017), “High-resolution transport-of-intensity quantitative phase microscopy with annular illumination”, *Sci. Rep.*, **7**(1), 1-22. <https://doi.org/10.1038/s41598-017-06837-1>.