Revealing an OSELM based on traversal tree for higher energy adaptive control using an efficient solar box cooker

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Abstract

The solar cooker represents a challenging scientific design. Its non-regular rechargeable system and the restriction imposed by the required availability quantity are the main issues. The use of a bar plate coated with nanolayer materials helps to stimulate and control the multifaceted performances for the cooker vessels. Further, it was noted that the traditional human methods are

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not capable to stimulate an efficient design for thermal applications, because the environment cannot adapt to the variable source. To overcome these challenges, we have used the approaches of adaptive neural network-based controls which further consider other parameters as the smaller family, measured conjunction, enormous period of feeding and below performances. Therefore, a novel solar cooker based on adaptive control through an online Sequential Extreme Learning Machine (OSELM) is presented and discussed. The use of OSELM enable also to detect an off-line physical activity process. The proposed solar cooker includes a bar plate coated with nanolayer materials (SiO_2/TiO_2 nanoparticles) which is responsible for physical accelerated activity of energy absorption. The feasibility scheme to validate this study is based on the calculation of extensive heat transfer process. By using the furious SiO_2/TiO_2 nanoparticles for the Stepped solar bar plate cooker (SSBC) the efficiency was increased by 37.69% and 49.21% using 10% and 15% volume fractions of nanoparticles.

Keywords: Solar cooker; Nanomaterials; OSELM; Stepped bar plate; Adaptive traversal tree.

1. **Introduction**

In a typical solar cooker, heat is contained within an enclosure where the internal air temperature is nearly 200ºC, which is sufficient for the cooking or baking of foodstuffs. An industrial process of monitoring for real-world applications include financial data analysis, elements predictions, and buyer performance estimates. Perez *et al*. [1] studied an online learning algorithm for flexible topologies and implementations of a neural networks system. Qiao *et al.* [2] have developed an online self-adaptive modular neural network (OSAMNN). The single-pass subtractive cluster algorithm enables updating the centers of radial-basis function (RBF) neurons for learning efficiency and accuracy. OSAMNN architecture is consider an online modeling of time-varying nonlinear input-output maps of the benchmark. Lughofer [3] studied an online learning algorithm that allows to select an appropriate assortment group and was updated to acquire more knowledge on changing patterns in evolving data streams as per Zhang *et al*. [4] and Zhou *et al*. [5]. In essence, solar cookers can be either a direct type in which sunlight makes contact with the cooking pot to transfer thermal energy directly or an indirect type in which thermal power is provided using a solar collector and head is supplied to the cooking unit indirectly [6]. Different types can be classified as solar panel cookers [7], box-type cookers [8], and concentrating cookers [9].

Numerous attempts have been made to study and develop different types of solar cookers to improve efficiency and broaden their applicability. Schwarzer *et al*. [10] showed the fundamental characteristics, design principles and testing standards for a simple solar cooker. They reported that several criteria concerning safety, portability, stability, endurance, robustness, and user-friendliness are essential considerations for this technology. In another study, Lokeswaran *et al*. [11] presented a solar cooker coupled with a parabolic dish and a porous medium using scrap material. Several tests proved that implementation of a porous medium increases the operating temperature, water temperature and optical efficiency compared to cookers with the receivers. Atul *et al.* [12] improved the performance of a solar cooker with a hybrid cooking pot (HCP). It was conversed with an average temperature for system measure and was reported as a comparison against TPP and COR which allowed the assessment of solar box cookers performances. Erdem Cuce [13] studied a cylindrical solar cooker and used it in microporous absorbers plates. They achieved with a conventional absorber a temperature of 110°C and the better performances reached 134.1°C using a triangular porosity. The maximum energy efficiency for triangular porosity was 34.6–21.2 while using trapezoidal porosity is possible achieve about 22.6–14.6%. Cuce [14] developed some solar box cookers and implemented thermal energy storage using Bayburt stone on the system. It provided stable, efficient and constant cooking, which achieved a range of about 35.3–21.7%, and 27.6–16.9% efficiency for the conventional cooker. Overall efficiency was 21.2–14.1% and 18.0–11.6% for a standard cooker. Zied *et al*. [15] developed a solar box cooker with outer reflectors and implemented a numerical analysis along with experimental studies. It was found that the thermal performance increased by using the high absorber plate temperature, which reduced the cooking time and used materials one hour at a stagnation test on the system. The analysis of a mathematical model gave correct outcomes which were also compared to the theory and experimental data. Negi and Purohit [16] studied an experimental investigation of a box-type solar cooker and employed them as a non-tracking concentrator. They concluded that using the concentrator solar cooker increased the temperature by 15–22°C, which is higher than the temperature of a conventional box-type solar cooker with a booster mirror. The boiling point of water is achieved faster at 50–55 min and an increase in heat collection of non-tracking reflectors of the cooker was caused. Palanikumar *et al*. [17] developed a solar box cooker and studied the thermal imaging process and verified against time series to consider the Fourier transform. It was used for the solar cooker characteristic considering an image reconstruction in order to improve the efficiency which was used in the algorithmic program and formed a thermal image fusion. Isabel *et al*. [18] coated gel-dipping with polysaccharides and prepared TiO_2 photocatalytic materials. They achieved some excellent performance for the photocatalytic activity of the final coated tiles which was described and conversed. The properties analyzed moves the photocatalytic action of the coatings. Hualong Liu *et al*. [19] coated TiO_2/WO_3 with a magnetic nanoparticle and used the absorption of visible light (solar light). The sixteen catalysts quickly mineralized ten dyes under the focus of sunlight. It was concluded that recycling with a magnet allows achieving excellent reusability. Abd *et al*. [20] studied the thermal behaviour of a solar cooker containing a tube. The most important improvement for cookers were related to the better potential of using nanographene particles.

Various scientists have documented the usage of furious SiO_2/TiO_2 nanoparticles which limits the productivity of solar thermal applications. The current study focused to improve the solar cookers performances by enhancing the thermal performance of the system. It focuses on the SSBC coated with a bar plate used in doping SiO_2/TiO_2 nanoparticle at a different ratio between 5 to 25%. Further, the SSBC study were improved by using an adaptive control through an online Sequential Extreme Learning Machine (OS-ELM) that uses an original binary search trees authorization in order to improve the SSBC capabilities at highest level.

2. Experimental materials and methodology

2.1 Furious SiO_2/TiO_2 nanoparticle analysis of SSBC performance methods

The analysis made to improve the performance of SSBC were conducted initially through an experimental method. The schematic diagram is shown in Fig. 1(a) and 1(b) which agree with one produced by Nahar [21]. The solar cooker has an area of 100 cm. The dimensions length x breadth for the absorption area is 100 cm x 100 cm and the frond wall height is 25 cm, and the height of the back wall is 30 cm. It is composed of a total of 16 stepped absorber bar plates with fixed inner sides with the left side consisting of 8 plates and right side contains 8 plates. The absorber bar plate was placed in the copper sheet and the inner stepped plate was placed in a mild steel sheet; designed accordingly to a preliminary step analysis. The transmission glass cover thickness of the material was 4 mm.

The SSBC was fabricated considering almost the same dimensions used in the the proposal presented by Verdugo [22], which used nanoparticles of furious SiO_2, TiO_2, mixture furious SiO_2/TiO_2, without nanoparticle (conventional solar cookers). It was studied, and the results compared the nanoparticles with the effect of different solar cooking performances. The experimental work was carried out from 10.00 am to 2.00 pm and variations of parameters such as temperatures of the stepped plate, bar plate, cooker, food stuffiness, moist internal air and glass cover were measured at every 30-minute intervals, and the experiment was conducted under the weather condition of KLEF at Vijayawada, Andhra Pradesh. The testing materials were milk and water, which were cooked for 45min with a mass of 1kg. The solar radiation data were measured using the TENMARS TM-206 solar power meter. The SSBC data were transferred to a laptop to evaluate the processes. The standard solar power meter enabled to measure all the parameters of different cookers using an indicator of 6-channels, one measure is temperature. It was measured the RTD - PT-100 type with sensor absorption of the thermocouple wire in a range of 0 – 800°C with ± 0.1°C correctness of data generated by the systems.

In the present study, the integration of nanoparticles aimed to increase the absorbed energy by the SMBC resulting in an output with higher quality. Therefore, to determine the performance of the system, the nanolayer which occupied the internal energy were calculated as follows;

$$E_{o\text{-}N} = \frac{m_w C_w (T_{f\text{-output}} - T_{f\text{-input}})}{A_c H_s t} + \frac{u(T - T_a)}{H_s} \quad (1)$$

where the amount of total energy ($Q_{total\ energy\ +\ N}$) absorbed by the coating is written as;

$$Q_{total\ energy\ +N} = \frac{E_o \cdot \Delta T_{\infty}\text{-}95}{\Delta t} \quad (2)$$

Besides, the total evaporation power ($\dot{Q}_{ep}$) used for the cooking material with a given fluid temperature is represented as;

$$\dot{Q}_{ep} = Q_{total\ energy\ +N} \cdot h_L \quad (3)$$

Therefore, the overall thermal efficiency of the SMBC was evaluated as;

$$\eta_{total\ energy\ +N} (\%) = \frac{\dot{Q}_{ev}}{H_s \cdot A_c} \quad (4)$$

2.2 Solar cooker control energy use of an OSELM:

The general approach of the extreme learning machine (ELM) proposed by Liang *et al.* [23] is utilized in several fields. The solar cooker uses materials (rice, water, milk, vegetables, etc.) as weights and the learning was performed under an initialization ELM. The solar cooker developed with a least-squares process and the use of parameter values of the appropriate heaviness from the production coatings. The heat transfer speed was found higher than in traditional neural networks. This method avoids convergence into local minima as per Guang *et al*. [24].

The samples used in S arbitrary allows to separate physical activity for $(X_i, T_i) \epsilon\ R^n \times R^m$. X_j that are represented as n × 1 vector for involvement and T_i is m × 1 vector for the goal. The active function g(·) and the hidden layer L uses an additive stimulation or Radial Basis Function (RBF) activation or both. The single-hidden layer feedforward the neural network (SLFN) approximately and is given for S working out of the solar cooker as zero error with existing cooking pots that are $\omega_i, m_i,$ and θ_i,

$$E = \sum_{i=1}^{l} \theta_i g(\omega_i, m_i, X_i) \quad (5)$$

where cooking materials (weights) are ω_i, m_i; which are then followed in biases of a hidden layer. Output based on cooking materials (weights) vector is θ. We can write this as

$$T = \Phi\theta \quad (6)$$

where Φ, θ are expressed for T

$$\theta = \Phi^{\intercal} T \quad (7)$$

Pseudo-inverse based on back point is Φ

$$\Phi^{*} = (\Phi^{\intercal}\Phi)^{-1}\Phi^{\intercal} \quad (8)$$

$$\Phi^{\intercal} = (\Phi^{\intercal}\Phi)^{-1}\Phi^{\intercal}\mathrm{T} \quad (9)$$

Where the rank (Φ) = L for cooking result is converted in a vector θ f=derived from eq. (7) which can be written as

$$\theta = (\Phi^{\intercal}\Phi)^{-1}\Phi^{\intercal}\mathrm{T} \quad (10)$$

2.3 Online sequential extreme learning machine (OSELM) approach for solar cookers:

The heat transfer with a more realistic order than that of the solar cooker values was generated line by line or hunk by a hunk considering the OSELM and ELM, respectively. The recursive least square process was estimated with a numerical technique as a result (weight) vector (θ). The OSELM is a significant part of two like (i) initialization (ii) sequential learning. Here, we have followed a strategy that consider cooking pots for the design as S = $\{(X_i, T_i) \nmid X_i \in R^n. T_i \in R^m, i = 1, \ldots.\}$, where RBF is the activation function of g(•) and the nodes of L hidden layer.

(i) Initialization:

The solar cooker values used to produce initial cooking pots were $S_0 = (X_i, T_i)_{i=1}^{S_0}$ and $S_0 \geq$ L and the initial result vector layer was written as

$$\theta^{(0)} = (\Phi_0^T \Phi_0)^{-1} \Phi_0^T T_0 \text{ where } T = \left[t_1 \ldots \ldots \ldots \ldots, t_{S_0}\right]^T \quad (11)$$

(ii) Sequential Learning

The solar cooker results were generated line by line or hunk by hunk for the heat values as $S_{k+1} = (X_i, T_i)_{S_{k+1}}^{S_k + S_{k+1}}$; then were created the outcome of matrix function for a hidden layer of Φ_{k+1}.

The cooker boiling materials (weights) were described as

$$B_{k+1} = B_k - B_k \Phi_{k+1}^T \left(I + \Phi_{k+1} B_k \Phi^{T_{k+1}{}^{-1}}\right) \Phi_{k+1} B_k \quad (12)$$

$$\theta^{(k+1)} = \theta^{(k)} + A_{k+1}^{-1} \Phi_{k+1}^T \left(T_{k+1} - \Phi_{k+1} \theta^{(k)}\right) \quad (13)$$

Finally, the design performance as a k=k+1 set of hunk cooking values was reported in a sequential learning development with the conclusion of the solar cooker.

2.4 OSELM neural network adaptive controller on Solar cooker

The algorithm of the solar cooker is controlled through DO concentration that links the heat transfer modes and manipulated the variables of the solar cooker which are expressed as

$$Y_{k+1} = f(X_k) + D(X_k) U_k + C_k \quad (14)$$

From Eq. (10) the heat is transformed as

$$Y_{k+1} = \bar{f}[X_k, w^*] + \bar{D}[X_k, v^*] U_k + \Delta_f$$

where the cooker is used in perturbation C_k and reptresent the sum of Δ_f which enable showing the fault of DO; further the absolute temperature values of cooking pots error and OSELM which generate each neural networks is described as

$$\bar{f}[X_k, w^*] = \sum_{i=1}^{L} w_i^* \, g(\alpha_i, m_i X_k)$$

$$\bar{D}[X_k, \upsilon^*] = \sum_{i=L+1}^{2L} \upsilon_i^* \, g(\alpha_i, m_i X_k) \quad (15)$$

The solar cooker is updated by OSELM principle using an online value derived from a sequential method

$$\begin{cases} B_k = B_{k-1} - \frac{B_{k-1}\Phi_k^T \Phi_k B_{k-1}}{1+\Phi_k B_{k-1} \Phi_k} \qquad \bar{\theta}_{k+1} = \bar{\theta}_k + B_k \Phi_k^T E_{k+1}^* \end{cases} \quad (16)$$

DO concentration of solar cooker is controller as

$$U_k = \frac{-\bar{f}[X_k, w^*] + Y_{k+1}^*}{\bar{D}[X_k, \upsilon^*]} + \mathrm{Q}_{total\ energy\ +\ N} \quad (17)$$

The eq. (17) which uses the energy process of the solar cooker is transposed into an OSELM approached as indicated in Fig. 2.

2.5 Analysis of solar cooker using Binary Search Tree:

The binary search trees analysis of a solar cooker is given in a sequence for $\sigma_k = (\sigma_1, \sigma_2, \sigma_3 \ldots \ldots \ \sigma_n)$. It is ordered as a set of n distinct elements for the process energy. This enable to obtain an energy heating process using the binary search tree of T (σ_k), with the components of $\sigma_1, \sigma_2, \sigma_3 \ldots \ldots \ \sigma_n$, as an iteratively formerly vacant tree of heat energy. The fundamental problems in computer science is solved by binary search trees using the data structures as indicated by Aho *et al*. [25] and Knuth [26]. The solar cooker is an important data structure and binary search trees area form a central role in investigations as algorithms. The solar cooker has higher energy levels of T (σ_k) and their parameters are considered to rely on the heat energy by a level which should be equal with a Quicksort (σ_k) for compounds on the axis accordingly to Cormen *et al.* [27]. Here, the heat energy was developed to reach the solar cooker using a binary search tree of (n) with an objective yield of σ_k = (1, 2, ... n) attained from higher energy levels of parameters to transfer energy on the system. The cooking pots are higher in average values of binary search trees and performed to understand the arrangements of energy levels which were not wholly haphazard. Haphazardness of the cooking pots was only partial. Finally, the thermal energy saved achieved greater levels of binary search trees in the solar cooker and only a small chance of partial arbitrariness.

The binary search trees used for the solar cooker is T (σ_k) and the thermal energy transfer rule is from the left side wall to the right wall with maxima the order of gain $\sigma = (\sigma_1, \sigma_2, \sigma_3 \ldots\ldots \sigma_n)$. The system made as primarily empty tree with roots of T (σ_k) as surveys and have a glass cover, step plate, bar plate, cooker and food stuffiness for $\boldsymbol{\sigma_1}$ of σ_k. The design was limited to σ then all the parameters value was reduced to σ_1, which can be written as

$$\sigma_k <= \sigma_k \{|\boldsymbol{i}|\, \boldsymbol{\sigma_i} < \boldsymbol{\sigma_1}\} \quad (18)$$

It allows gaining the energy in an inductively mode as $\sigma <$.

σ is considered the control of the parameters which increases in the same manner as σ_1 is described as

$$\sigma_k >= \sigma_k \{|\boldsymbol{i}|\, \boldsymbol{\sigma_i} > \boldsymbol{\sigma_1}\} \quad (19)$$

The solar cooker is the right subtree for σ_1. T (σ_k) is gained as an inductivity of $\sigma_k >$.

The solar cookers transmission of heat energy as shown in Fig. 3(a) notes a higher energy level of T (σ_k). The solar cooker absorbed a higher energy level (σ_k) and the most extended pathway from the root to the leaf contains several nodes. The internal heat transfer is a maximum level of σ_i, maxima of σ if $\sigma_i > \sigma_j$ for all parameters bounded by j ∈ [i −1]. The energy was saved using the parameters of (σ_k) ≤ height (σ_k) and the amount of heat energy to the maximum value was equivalent to the dimension of all sidewall pathways in a tree of T (σ_k).

2.5.1 Assumption by the cooker

Binary search tree (BST) is empty or full based on the following properties:

- The solar cooker parameters are BST and must be discrete.
- It is smaller than the root and inserted at the left side of the subtree.
- The setting is larger than the source added at the right side of the subtree.

In a binary search tree, the parameters of the solar cooker are arranged in such a way that for any node the heat energy sources on the left side are smaller than that node and the heat energy source on the right side which is more significant than that node. This means that the heat energy in the left subtree is smaller than that key element in the right subtree and is more significant than that essential of the stepped solar cooker. It is easy to search for key factors. Time taken for searching an element in a tree depends on the height of the tree.

1. Height of a binary search tree minimum is T (σ_k).

2. Height of the binary search tree maximum is σ_k.

The solar cooker performs rotation to convert more gigantic height binary search trees to smaller height binary search trees.

2.5.2 Algorithm:

1. The solar cooker starts from the root.
2. Compare the elements with the root element. If the component is higher than the root, then the aspect is towards the right subtree.
3. If the component is less than the root element, then the feature is towards the left subtree.

2.5.3 Binary search tree insertion, deletion diagram with temperature values by solar cooker

In a binary search tree, we take an element as a root element from the given ingredients. If the considered item is higher than the root element, we insert it on the right subtree, if the aspect which we take is less than the root element we enter it on the left subtree as indicated by Roberto De Prisco [28] and Navin Goyal and Manoj Gupta [29].

2.5.4 Experiment

The experiment was conducted on an Intel Core i5 8th generation processor, with a RAM capacity of 8GB and secondary memory capacity of 1TB. The experiments lasted for one year. Java SE version 13 was used for the implementation of this experiment, and JDBC was used to access the database. Data was stored in the MySQL version 8.0.4 database. The system clock was used for time stamping and the readings of the experiment. A multimeter was used to read the temperature of various components in the experiment.

2.5.5 Memory Organization:

We used two tables, one for "bookkeeping" and another for the "look up" table. The "bookkeeping" table has three entries in each row. Entries in the table contain "timestamp", "material" and "rtemp". The "Timestamp" contains information related to the time at which the reading for the experiment was taken and it is stored as a long integer with size 8 bytes. "Material" gives information about the item cooked in the stove and it was stored as a character of size 25 bytes. "rtemp" corresponds to the room temperature in which the various components readings have been recorded. The total size of a row in the "bookkeeping" table is 37 bytes. It is a dynamic table; the size of the table increases when more significant numbers of readings are taken in the experiment. The second table was fixed in length with a capacity of 355 entries. Each entry consists of "day" and "next" fields. The "day" field corresponds to each day of the year in which the experiment readings were taken. The "next" field points to an address of a linked list. The total size of each entry is 8 bytes, with each "day" and "next" field having a size of 4 bytes. The overall memory organization of the experimental setup is shown in Fig. 3b.

The linked list consists of a collection of nodes. Each node consists of three fields viz. timestamp, ptr and next. The "timestamp" holds the value of time at which the reads have been taken and it is a length of 8 bytes. Pointer "ptr" is a pointer in a binary search tree that holds the reading of an experiment for various components in the stove. The "next" is the pointer to the next node in the linked list. The fields "ptr" and "next" each have a size of 4 bytes. So, the total size of a node is 16 bytes.

2.5.6 Working Principle

When milk, bread or othe food was cooked in the stove, its reading was taken. The various components of the stove's temperature were measured using a multimeter. The time of the reading was taken as a timestamp by a digital clock. This timestamp, the material cooked, and the room temperature were all recorded in the bookkeeper table. For example, the timestamp "1606979426043" contains the following information; '12', month- '3', year- '2020', hour- '08', minutes- '10', second- '26' and millisecond- '43'. This timestamp helps to organize, store, retrieve, and find the information related to the experiments. The timestamp is taken from the table to extract the month-day readings taken. Months and days are converted into a number ranging from 0-365 days in a year using a function. Based on this converted value, it is then mapped to the address 10568 in the "lookup" table. In this table, 71 is the value stored in the "data" field and 1045 is an address in a linked list of Binary Search Tree (BST). Stored readings of an experiment node were created in the linked list with a value "1606979426043" for "timestamp", 2092 for the pointer to address of BST and 1074 pointer of the next node in the linked list. This linked list will be a sorted list, consisting of entries of all experiments carried on a particular day. By inserting a value in the linked list, the entire list will be searched and inserted in the respective places.

Binary Search Tree was used to store the reading of the experiments. It is an extension of a binary tree and provides an efficient way of organizing the elements for storing, retrieving and finding information. Accessing an element in BST takes a time complexity of $O(\log_2(n))$ with a linear search with O(n). It is therefore called a logarithmic search. To make the tree searchable, the elements in the tree must be comparable and understand the relationship between the elements. In this condition each element must exhibit a Total Order Relationship property. When two elements are compared with each other, there exists a property called Comparable. This Comparator exhibits the following set of rules:

1) Reflexive Relation – If every element in the set maps itself in the set. A relation is reflexive if: $(a,a) \in R \ \forall a \in A$, where R is the relation, A is the set and a is the element in the set.
2) Anti-Symmetric Relation – Relation R of a set A is anti-symmetric if (a, b) ∈ R and (b, a) ∈ R, then a=b.
3) Transitive Relation – If (a, b) ∈ R and (b, c) ∈ R, then (a, c) also belongs to R, where a, b, c is the element in the set and R is the relation.
4) Comparable Relation – For any a, b, in the set, either $a \leq b$ (or) $b \leq a$.

A Binary Search Tree is a special tree that contains an ordered way of arranging nodes. The elements on the left side of the parent are lesser and the elements on the right side of the parent are greater. A node is represented by two values as "comp" and "temp" as component and temperature, with two pointers as "l child" and "r child" as the left child and right child. Component and temperature values correspond to components used in the experiment and its temperature respectively, while pointer stores the address of its children. The size of the "comp" and "temp" value is 15 bytes of character and 2 bytes of the integer, respectively. Both the pointers are two bytes in integers. The first node in the binary search tree is identified by a root as a pointer.

2.5.7 Insertion

Step 1:

When inserting a node "bar plate" with a BST temperature of 165 degrees as shown in Fig. 3b(i), it checks for the Root pointer. Since, the Root pointer is NULL initially, it creates a new node and changes the Root value to point the address of a newly created node. Here, the newly created node value is 3082, and it is stored in the Root.

Step 2:

The BST needs to compare the root node with the value in order for the second node to be inserted in Fig. 3b(ii). Based on the comparison, the new value is greater than the root node value in terms of alphabet comparison. Again, the comparison must continue on the right side of the root. Since, the right child of the root node is NULL, a new node must be created and inserted into the right child of the root node. The right child of the root node is assigned a value of 3120, which is the address of a newly created node.

Step 3:

The node to be inserted in BST takes a value of "sidewall" and "78" for "comp" and "temp" fields. This "sidewall" is compared with the root node and right child of the root node. It is more significant than both the nodes, so a new node is created, and its address assigned to the right child pointer of cooker node as 3160 in Fig. 3b(iii).

Step 4:

The new node is inserted into the left child of "glass cover" with an address value of 3200. Before insertion, it is compared with the "bar plate", "cooker" and "sidewall" nodes. During comparison it was found that the value was greater for the "bar plate" and "cooker" nodes, whilst it was less than the "sidewall" node. It was therefore inserted into the left of the "sidewall" node in Fig. 3b(iv).

Step 5:

The new node with a value of "foodstuff ness" as "comp" and "120" as "temp" was inserted into the left child of "glass cover" with an address value of 3250. Before insertion, it was compared with "bar plate", "cooker", "sidewall" and "glass cover" nodes. During the comparison, the value for the "bar plate" and "cooker" nodes were found to be greater, while it was less than that of the "sidewall" and "glass over" nodes. So, it was inserted into the left of the "glass cover" node in Fig. 3b(v).

Step 6:

A new node containing the value of the "loss" as "comp" and "10" as "temp" was inserted into the right child of "glass cover" with an address value of 3280 in Fig. 3b(vi).

2.5.8 Deletion

Case 1 (Node as leaf node):

It is easy to delete a node with no child. The node to be deleted in this case is "loss". The node "loss" is compared with the root node "bar plate" in the binary search tree. In alphabetical order the node "bar plate" comes first followed by "loss", and the comparison is then moved to the right side of the root. This continues until the desired node has been reached. It is illustrated as five steps in Fig. 3b(vii). Once the desired node has been reached, that node is then deleted and the pointer pointing to this node is assigned a "NULL" value ac by Mantheya and Reischuk [30].

Case 2 (Node with one child):

If the node has one child, it is deleted by adjusting its parent pointer that points to its child node. Let us consider a binary search tree, as shown below. To delete node the "loss" in the tree, the "loss" is compared with the root node "bar plate". The "loss" is greater than "bar plate" in alphabetical order; the comparison is moved towards the right side of the root node. This comparison continues until the desired node that was deleted is found. The node "loss" has one child as shown in Fig. 3b(viii).

The node "loss" is replaced by the node "foodstuff ness" value as followed in Fig. 3b(ix). The left child of node "loss" is deleted, and the left child pointer is assigned the value "NULL".

Case 3 (Node with two children):

It is difficult to delete a node that has two children, as shown in Fig. 3b(x). The general strategy is to replace the data of the node to be deleted with its smallest data from the right subtree. Consider a binary search tree in the example, and try to delete the "glass cover" node which has two children. The "glass cover" will be compared with the root node "bar plate". The "glass cover" is greater than "bar plate" in alphabetical order; a comparison has moved towards the right side of the root node. This comparison continues until the desired node deleted is found. The node "glass cover" has two children. Now, the right subtrees smallest node must be replaced with the node in order to carry out the deletion. Then, the smallest node from the right subtree is deleted.

The right subtree least node value is then replaced in "glass cover" node in Fig. 3b(xi). The loss node is deleted from the tree and the right child of the "loss" node is replaced with NULL.

2.6 Simulation model of solar cooker results

Binary search tree which follow an insertion, and deletion diagrams have analysed the temperature of the values as ways of OSELM controlling stability for solar cookers. The performance of the solar cooker was evaluated in order to create a performant model estimation. It was verified for the validity of the control energy and its operating parameters which allows to improve the system solution.

The simulations model were verified on the origin Pro2020 version, and the Microsoft Windows service 2010 R2 were used to record the value of atmosphere and the degree of its CO concentration. The evaluation of the system convey a standard analysis which is based on an integral of Absolute Error (IAE), Integral of Square Error (ISE) and maximal Deviation from the setpoint of (D^{max}).

$$\text{IAE} = \int_{to}^{t1} |R(t) - Y(t)| \, . dt$$

$$\text{ISE} = \int_{to}^{t1} (R(t) - Y(t))^2 . dt$$

$$(D^{max}) = \max|R(t) - Y(t)| \qquad (20)$$

where R(t), Y(t) refers to solar cooker Input, output and IAE designates the transient response. ISE is suitable damping of (D^{max}) which indicates the control for solar stability cooker as found in Hong *et al*. [31] and Guang *et al*. [32].

$$\lim_{k\to\infty} \sigma_k \left[\frac{e_{k+1}^{*2}}{\left(1+\sigma_k \Phi_k P_{k-1} \Phi_k^T\right)^2} - \varepsilon^2 \right] \times \mathrm{Q}_{total\ energy\ +N} = 0 \qquad (21)$$

$$\lim_{k\to\infty} sub \; \frac{e_{k+1}^{*2}}{\left(1+\sigma_k \Phi_k P_{k-1} \Phi_k^T\right)^2} \leq \varepsilon^2 \times \mathrm{Q}_{total\ energy\ +N} \qquad (22)$$

The comparison for the online learning algorithms is studied within the solar cookers through the heat transfer to verify all parameters of the inherent characteristic of the OSELM such as SVR, Go-GP GOD-LR, respectively. The large-scale data were not considering handles for Go GP and were adapted precisely with streaming data. These online learning methods have compared against the solar cooker parameter values of cooking pots, boiling materials and data produced by the BSM1 model and controlled through an evasion PI organizer. Two separate groups of 1450 and 1000 made up the total number of set data collected by solar cooker data, and cooking materials data. Table 1 illustrates the solar cooker parameters of OSRLM and the fastest working process is online SVR. The training time of OSELM is the fastest among these plans, especially for Online SVR. OSELM is still the lowest Root Mean Square (RMSE) compared with other methods. As shown in table 1, the solar cooker temperature analysis of OSELM utilizes high-speed methods, especially for online SVR. The lower root means square error (RMSE) is computed in this process. Besides, we found that for R^2 that is an online process developed for the GOGP has a higher value than SRV. The solar cooker experiment indicated that the OSELM process which is simulated using machine learning methods generate an excellent solution for their application.

3. Results and discussion

The weather conditions analysis of the solar cooker was fixed in KLEF at a solar energy laboratory. The parameters performance is used for a variety of volume fractions (5%, 10%, 15%, 20% and 25%) by the SSBC, which enable to evaluate the effects of temperature such as ambient, glass, moist air, bar plates, stepped plates, cookers (input, output), food stuffiness and solar radiation. It was experimentally evaluated at every 30 mints as shown in Fig. 4(a to e). The parallel experiments were used for the systems to analyse the solar radiation, and then ambient temperature. They were calculated for the various weather conditions for solar intensity and ambient temperature as showed in Fig. 4(a to e), average values are 870W/m^2 and 34°C. The maximum during the peak was up until 3.00 pm and abridged in the evening, reducing the system. The SSBC endorsed that the uses of 10% and 15% furious SiO_2/TiO_2 nanolayer allows enhancing the average temperature by an increase around 16.7% and 27.4% as per Fig. 4(b & c). This has been compared to that of the systems with nano seams coated bar plates, and stepped plates of energy absorption for single furious SiO_2, TiO_2, and without SiO_2/TiO_2. The temperature was varied on the SSBC when were used various ratios of 5%, 10%, 15%, 20%, 25%. Such as the nanofluids that uses a bar plate absorption were 58.4, 63.4, 64.7, 63.2, 63.0 ± 0.1ºC, and stepped plates had 58.4, 62.6, 64.5, 61.5, 62.2ºC as per Harmim *et al.*, [33]. The furious SiO_2/TiO_2 nanolayer was used as coating material to improve the internal heat transfer modes that works as a link contact between bar plate, stepped plate, moist air, and control the cooker temperature that concurrently improved the heat energy functions. The use of 10%, 15% of furious SiO_2/TiO_2 nanolayer in the SSBC enable to achieve a temperature of 63.4, 64.7 ± 0.1ºC which is higher with about 20% and 25%, respectively when compared to traditional design. Since the glass and cooker temperature are higher, they can achieve a higher performance of about 9.14, 13.14% and 8.14, 11.46%, respectively. Indeed, this is higher than of using a solar cooker with single elements, without a nanolayer. Fig. 4(a to e) shows the hourly variations in the characteristic for the SSBC that considers the temperature range in glass, bar plate steeped plate, moist air, cooker and ambient temperature. The experiment conducted to different ratios of furious SiO_2/TiO_2 nanolayers were evaluated also for typical ambient temperature in a parallel system. The different rates of 5%, 10%, 15%, 20%, 25% of the furious SiO_2/TiO_2 nano seam were used to fulfil the average bar plate temperature of the system. There was obtained a temperature around 58.3, 61.6, 64.5, 59.9 and 59.1 ±0.1ºC, respectively for each individually coating ratio. Therefore, the thermal conductivity associated to the furious SiO_2/TiO_2 nano seam increased with a ratio of 10%, 15%, and reduced by the rate of 20%, 25% in bar plate temperature. It was used with the mixed nano seam for the temperature in bar plate which is gain with the heat energy of the SSBC that increased by 10.34%, 15.17%, for a ratio of 10%, 15%. The performance of the SSBC was enhanced for cooking, which play an essential role in respect to the material absorption. The average temperature produced in the bar plate can increase by 9.42% and 14.23%, respectively.

Fig. 5 shown the hourly variations of temperature for the SSBC considering the maximum temperature variation which was enhanced using a single elements, without nanoparticles that is 0.73, 0.77±0.01kg/m^2 and with coated of SSBC with 5, 10, 15, 20, 25%. The furious SiO_2/TiO_2 nanolayer achieved a ratios of 0.74, 0.76, 0.78, 0.77 then 0.76±0.01 kg/m^2, respectively. The highest solar radiation was achieved from 12.01 to 13.00. The SSBC used in 1kg water and milk boiling virtually for 25min. using single milk nanoelements (SiO_2, TiO_2) and without nanoparticles as shown in Fig. 6. The bar plate temperature, as achieved by the SSBC, was raised virtually at a temperature of 167ºC during working hours. Sagade *et al*. [34] and Bhavani *et al*. [35] were verified and the data were introduced in Table 2. The cooking performance with different materials was achieved using the temperature ranges of various weather conditions of absorption and experimentally verified during the cooking period of October 2019 to April 2020. We have tested it with the help of SSBC considering 1kg rice and SiO_2/TiO_2 nanolayer which after just 105 minutes reached the higher temperatures. This was compared with a single nanolayer which reach the highest temperature only after 145 to 155min, whilst the one without nanolayers was much slower cause it reached the maximum temperature only after 190min. The ratio of 10%, 15% used in SSBC increased the heat energy performance by 21.5%, 24.6% and was compared to single elements without nanolayers. Similarly, SSBC coated and the bar plate reached a higher temperature and a performance more than 20%, 25% when comparing to without nanolayers. It was noted that the peak times for bar plates are during the sunlight periods. Fig. 7 indicated the performances of the SSBC with a ratio of 5%, 10%, 15%, 20%, 25% SiO_2/TiO_2 nanolayers which enable the following efficiency 31.77%, 37.69%, 49.21%, 36.99% and 34.66%, respectively.

3.1 The Solar Cooker Strategies with Evaluation for Energy Control

SSBC rely on BSM influent load data for the temperature analysis of the initialization condition of the system. The analysis of the solar cooker was an important one-year simulation with data of 0.0001. The SSBC control simulation model was selected as an initialization data which was used on an OSELM founded adaptive controller for the BSM model. The performance of the SSBC vary as a function of weather conditions, as shown in Fig. 8a and 8b. Thus, the weather conditions variation can dictate the algorithm variable which finally drives the performance of the cooker. The error analysis of the cooker was controlled by a flexible set point range of ± 0.05 mg/day frequently.

Further comparison of the SSBC with some controller approaches for different weather conditions are shown in Table 3. SSBC is controlled by the IAE, ISE and D^{max}, which were calculated for 0.0564, 0.0057, 0.0472 and better values of the system. The regular performance of the SSBC was evaluated in order to establish a fast-moving transient with a response to appropriates of dampening. It uses the heat transfer and excessive permanency of the SSBC individually.

Conclusion

A novel solar cooker was designed applying a composite nonlinear design which is based on a neural network with a controlled approach to generate superior heat transfer. The used neural network enabled an innovative control of responsibilities and faster period of development. The following conclusion were drawn from this research:

1. The SSBC was produced using a superior control effect and it was simulated under the OSELM based adaptive control on the recursive least square method. This was well integrated on

the thermal process for the solar cooker design. Further, the neural network-based on the control approach allowed to detect the most appropriate cooking materials for solar design in order to reduce the biases of hidden nodes.

2. The use of SiO_2/TiO_2 nanolayer coated, of different ratio, on the bar plate which was integrated within the solar cooker permitted to obtain a higher temperature and in turn reduced the cooking times. It is revealed that the SSBC is a key element to enhance the heat transfer modes. Moreover, the SiO_2/TiO_2 nanoparticles reached a slightly higher average temperature for the glass, cooker, bar plate and stepped plate, which is the order of 12.5%, 16.4%, 16.5%, 16.3%, respectively.

3. Overall, the coated system has an efficiency much higher when comparing to one without nanoparticles coating. The binary search trees algorithms were able to improve the product price to its maximum while providing an optimum cost for maintenance for the solar cooker. The time-stamped storage and recovery temperature were the main attributed used to validate the performances of novel proposal.

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Nomenclature

A_c	-	bar plate area of cooker (m^2)
$E_{o\text{-}N}$	-	nanolayer volume for the internal energy (kJ)
C_w	–	Heat transfer capacity to water (L)
h_L	–	Convection heat transfer coefficient loss of cooker (W/m^2)
M_w	–	Mass of water (kg)
$T_{f\text{-output}}$	–	Food stuffiness of output temperature (ºC)
$T_{f\text{-input}}$	–	Food stuffiness of Input temperature (ºC)
H_s	–	Solar Radiation (W/m^2)

t – Time (S)

T_a – Ambient Temperature(ºC)

T - Temperature(ºC)

L - Cooker Length (m^2)

k - design performance of the thermal conductivity (W/m^2)

U_k - Control for the solar cooker performance (W/m^2)

$\boldsymbol{\sigma_1}$ of σ_k - glass cover, step plate, bar plate, cooker, food stuffiness(ºC)

T(σ_k) – The binary search trees used for the solar cooker (ºC)

u - Convection heat transfer coefficient (W/m^2)

$Q_{total\ energy\ +\ N}$ - amount of total energy (W/m^2)

$\dot{Q}_{ep}$ - Total heat transfer as evaporation power (W/m^2)

V - Volume (m^3)

$\eta_{\ total\ energy\ +N}$ - Overall thermal efficiency generated by the SMBC (%)

Φ - Pseudo-inverse based on the back point (ºC)

$\omega_i, m_i,$ and θ_i, - solar cooker with zero errors for an existing cooking pots (ºC)

IAE - standard for analysis of an integral of Absolute Error (ºC)

ISE - Integral of Square Error (ºC)

D^{max} - maximal Deviation from the setpoint (ºC)

R(t), Y(t) - referred by solar cooker Input, output (ºC)

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