Peer Review File

Article information: https://dx.doi.org/10.21037/jtd-21-1767

Response to reviewer A:
Special thanks to reviewer A for the good comments.
Comment 1&2: Major Issues
1. The demarcation between deep learning, machine learning, and AI. The authors may want to have a quick look at the brief definitions in the introduction and Table 1 of this paper: (https://internal-journal.frontiersin.org/articles/10.3389/frai.2021.652669/full ) Abdulkareem M and Petersen SE (2021) The Promise of AI in Detection, Diagnosis, and Epidemiology for Combating COVID-19: Beyond the Hype. Front. Artif. Intell. 4:652669. doi: 10.3389/frai.2021.652669
2. As a result of the lack of demarcation the terms in 1. above, the keywords of the search criteria can be faulty: `Artificial intelligence', `Neural Network Model', `Deep learning' and `Arrhythmia'. My initial thought was that the author wants to focus on deep neural networks and arrhythmia – given that deep learning is a type of neural network but with a lot of hidden layers. If that is the case, then the authors should make this point clearer. Moreover, it should be noted that many people refer to deep learning to mean convolutional neural networks for solving computer vision problems (such as in medical imaging) – and that is not the sense in which deep learning is used in this paper, and that emphasizes the need for the authors to be very specific in their choice and use of words.
After reading lines 143 to 145, the cited paper “Classification of electrocardiogram signals with support vector machines and particle swarm optimization”, I now think that the authors used the words ‘deep learning’ to mean ‘machine learning’. As the paper in https://internal-journal.frontiersin.org/articles/10.3389/frai.2021.652669/full noted, deep learning and support vector machines are types of machine learning. Particle swarm optimization is an optimisation method often used in AI. And later again, the authors used the work ‘convolution neural network’. The lack of clear definition of what the authors’ mean by deep learning keeps one guessing.
Reply 1&2: AI in our study mainly refers to its main stream methodology in the application in cardiology nowadays——ANN which include deep learning and CNN. And the searching key words were designed accordingly. AI refers to human-like intelligence computer algorithms developed to solve specific problems. The methodologies of AI are changing with the improvement of technology, and machine

learning (ML) sometimes may refer to as AI in cardiological guideline because the major technique of AI applied in this field nowadays is ML. Artificial neural networks (ANN) including deep learning and convolutional neural network is constituted by an input layer, hidden layers and output layer of neurons which respectively processes information that is fed in or put out from the model. Searching formulate "TS= ()" was applied which can automatically search all relevant topics and avoid including too much irrelevant articles.
Changes in the text: We have made changed as advice by defining the concept and specified what is the main content of our manuscript (see Page 4, line 73-75).

Comment 3: Minor Issues
1. It would be useful to include in the discussion section why the authors think that study on deep learning of arrhythmia began to increase 2017 according to Figures 2 and 3.
Reply 3: We searched for detail technology revolution which prompted the application of machine learning in arrhythmia and found out event which could be evolution landmarks for ANN. We believed the technical development ultimately led to the increasing publication relevant in this realm.
Changes in the text: We have analysis why we thought study on deep learning of arrhythmia began to increase 2017 according to Figures 2 and 3 as advised (see Page 13, line 269-274)

Comment 4: Minor Issues
We may want to remove this statement "The annual number of publications reached a peak in 2020 (Fig. 2)" on line 127 given that as of July 2021 when the data was collected, we are only in the middle of 2021 so one wouldn't say that there are more citations in 2020 than 2021.
Reply 4: We agreed with reviewer and removed the original sentence.
Changes in the text: Changes were made as advised (see Page 8, line 163-165)

Comment 5: Minor Issues
Line 177 mentioned Figure 13 (should be Figure 8) – but there isn't any Figure 13 in the manuscript.
Reply 5: The Figure 13 should be Figure 8c. We reorganized the order of the context by the appearance order of the picture.

Changes in the text: Changes were made accordingly in line 228 (see Page11) and line 218-220(see Page 11)

Comment 6: Minor Issues
In the keys of Figure 9, it should be ‘infarction’ (not ‘infartion’)
Reply 6: Thanks! We have revised this mistake. We changed the format of Figure 9 in GraphPad Prism version 9.1.1 (GraphPad Software Inc, California, USA).
Changes in the text: Change was made in Figure 9.

Comment 7: Minor Issues
In Table 8, it should read ‘neuro-fuzzy’ (and not ‘fuzzy neuro’)
Reply 7: Thanks! We have revised this mistake.
Changes in the text: See Table 8.

Comment 8: Minor Issues
The sentence ‘As the first bibliometric analysis of deep learning in arrhythmia’ in line 214 doesn’t make sense. Is the sentence complete? Please check.
Reply 8: We revised the sentence by combining two sentences which relevant.
Changes in the text: See line 263-269 Page 13.

Comment 9: Minor Issues
From lines 216 to 218 do not make sense “but booming over the last 5 years as the popularity of the concept of artificial intelligence and partially due to the growing number of output index in the number of publications in the WoSCC database”. Are we suggesting that the increase in publication is due to the popularity of AI? I would disagree with that mainly because the recent popularity in AI can be attributed to recent advancement in high-performance scalable computers – which in turn have prompted research and development into new algorithms and applications. Again see more details in https://internal-journal.frontiersin.org/articles/10.3389/frai.2021.652669/full and the references therein.
Reply 9: We agreed with the reviewer on this point. The advancement of computer technology including hardware and software are the foundation of development of AI in a long-term perspective for sure. But we thought the popularity of the concept was partially a reason even it sounded a little bit non-academic. Because we live in a world that capital plays an important role in the development of technology, and popularity of a high-tech concept does attract investment into this field which may

prompt its growth and booming. We may find the importance of social focus in the development of AI from the whole history of it (see https://pubmed.ncbi.nlm.nih.gov/33038991/). The history of development of AI over the last 70 years demonstrated that there were two so called AI winters and it usually started from a very high expectation of the public and stakeholders who regarded this technology as a very promising tool in the future but eventually it failed to meet such kind of expectation. We thought that there could also be over-estimation in the third AI booming in this century which marked by the popularity of the concept and increasing number of publications in relevant field. And bibliometric phenomenon of this kind can be seen in many concepts which start from over-estimation in the very begining followed by increasing number of publications. But people are more rational nowadays and algorithms and application are developing very quickly. We are still optimistic about the development of AI and AI in arrhythmia. Moreover, we considered the higher accessibility of data due to digitalization of clinical information and other information could also contribute to its popularity.
Changes in the text: See line 263-269 Page 13.

Comment 10: Minor Issues
The last part of line 265 to 266 doesn't make sense: "and in another aspect the lack of clinical data." Please check.
Reply 10: We revised the original sentence which could be misleading.
Changes in the text: See line 326-327 Page 15.

Comment 11: Minor Issues
I do not understand the last part of line 278: "and more accurate algorithmically artificial neural network (ANN) could have more capacity in model fitting"
Reply 11: In non-linear prediction, ANN owns more capability in model fitting and we have added the premise to make it understandable. As a matter of fact, support vector machine (SVM) can be regarded as a two layers neuron when linear regression model can be expressed as one layer model by comparing with deep learning model which usually had three layers. In non-linear prediction, SVM and deep learning (DL) model which were closely related could have more capability in model fitting. See https://www.sciencedirect.com/science/article/pii/S0735109718344085?via%3Dihub. Practically, SVM and DL were not totally separated in application and could be combined together to create new neuron networks model. But as we can see in Figure

8b, after 2017 the term SVM never showed up, suggesting that SVM was then rarely applied in realm of AI in arrhythmia and ANN became the mainstream in this area.
Changes in the text: See line 339-345 Page 16.

Comment 12: Minor Issues
Regarding line 279, generally, I do not think this statement is true: "Basically, the less the hidden node, the lower the estimation error which was determined by the amount of data". I probably don't understand what you mean. A clarification would be very useful.
Reply 12: Adding hidden node in a layer can strengthen the fitting of the ANN model to data and lower estimation error. But too much nodes can bring the problem of over fitting. We adjusted the original sentence to make it understandable.
Changes in the text: See line 345-347 Page 16: Basically, with an appropriate number of hidden node in a layer, the neural network model will have a low estimation error which was determined by the amount of data and avoid over fitting.

Comment 13: Minor Issues
It would be useful to define OPTIMA (OPtimal Target Identification via Modelling of Arrhythmogenesis) in line 298 instead of leaving the reader to wonder.
Reply 13: We added specific definition of this terminology.
Changes in the text: See Page 17 line 367-368: However, recently OPTIMA approach (termed as optimal target identification via modelling of arrhythmogenesis) was proposed by Boyle et al with identification of optimal atria target in persistent atrial fibrillation patients via modelling of arrhythmogenesis.

Comment 14: Minor Issues
It would be useful to re-read the article to correct typos and grammatical errors. Some spelling and grammatical errors identified include:
Line 51 – Abbreviation of MI should be 'infarction' (not 'infraction').
Line 55: Should read '… though it had twice been through "artificial intelligence winter".
Line 59: Should read '' AI is gradually being used in many applications in clinical practice."
Line 59 – 63: I would write these as follows (from 'Especially…'): "In particular, cardiovascular medicine which processes diversified format of nonlinear and visual

clinical data, such as electrocardiograms (ECG) and echocardiograms, requires a better and different approach from traditional linear analysis. Moreover, hemodynamic and electrophysiological data are increasingly captured by the popularity of wearable devices"

Line 66 – 68: I would write these as follows: "Thus, a lot of recent study focus on the big data processing of these separate information in cardiovascular data and imaging due to the digitization of daily clinical activities which can hardly be possible in the past."

Line 74-76: I would write these as follows: "Having been performed for nearly one hundred years, quantitative studies, especially bibliometric methods, are increasingly being developed and used to estimate the variations of productivity of countries, authors, institutions and journals."

Line 219: I would write these as follows: "We may expect the development of deep learning in arrhythmia promising with numerous future potentials."

Line 264: 'makes' should be 'make'

Line 273: I would write "Advancement in data space augmentation as well as synthesis using deep learning models are making the application of AI in detection and treatment of arrhythmia feasible."

Line 277: 'is a' and not 'is an'

Line 291: I would write "For patients with angina, this monitoring could not only monitor the onset of myocardial infraction (MI), but could also help in predicting it."

Line 310: I wouldn't use "What' more"

Reply 14: We made changes accordingly in the manuscript.

Changes in the text:

See Page 3 line 54: Abbreviation of MI was revised as infarction;

See Page 4 line 71: As a branch of ML, artificial neural network (ANN) is becoming increasingly promising in medicine, despite twice experiencing the "AI winter".

See Page 4 line 78-79: By promoting data classification and comprehensive decision making, AI is gradually being used in many applications in clinical practice.

See Page 5 line 86-89: Thus, a lot of recent study focus on the big data processing of these separate information in cardiovascular data and imaging due to the digitization of daily clinical activities which can hardly be possible in the past.

See Page 5 line 96-98: Having been performed for nearly one hundred years, quantitative studies, especially bibliometric methods, are increasingly being developed and used to estimate the variations of productivity of countries, authors, institutions and journals.

See Page 13 line 276-277: We may expect the development of ANN especially deep learning in arrhythmia promising with numerous future potentials.
See Page 15 line 324: Moreover, the keywords “MIT BIH arrhythmia database” make up a ……
See Page 16 line 334-336: Advancement in data space augmentation as well as synthesis using deep learning models are making the application of AI in detection and treatment of arrhythmia feasible.
See Page 17 line 359-361: For patients with angina, this monitoring could not only monitor the onset of myocardial infraction (MI), but could also help in predicting it.
See Page 18 line 382-383: We did not take self-citation into consideration.

Response to reviewer B:
Comment: The manuscript “Research output of artificial intelligence in arrhythmia from 2004 to 2021: a bibliometric analysis” by J. Huang et al. presents an overview over publications published between 2004 and 2021 dealing with the application of artificial intelligence in the field of cardiac arrhythmia. The authors present statistical analyses regarding the year of publication, the authors of the studies, characteristics of keywords and other similar features.
I believe that the presented results are correct and the statistical interpretations have been performed in an appropriate way. However, I do not recommend publication of the presented study. To my opinion, the statistical analyses of quantities like citations, keywords, or authors alone could be useful, but does not contain a sufficient amount of scientifically relevant findings.
The study focuses mainly on features related to the literature on a surface level. Scientific discussions about different methods, comparisons of machine learning algorithms or an evaluation of the approaches used in the papers do hardly appear. That is, why the conclusions drawn by the authors also remain on a surface level, only.
I agree with the authors, that the field of A.I., in particular in the medical context plays an increasing role in the community and that potential applications become more and more important. Therefore, I would like to encourage the authors, that dealing with these novel algorithms and comparing different approaches, in the field of cardiac arrhythmia on a detailed scientific level, for example, would, to my opinion, be of high interest in the community.
Reply: Thanks for the comment of the author. In this article we mainly aimed to discuss the application of AI in arrhythmia in bibliometric approach and analyzed the

underlying reason that led to the change in this area. Specifically, we revealed that from 2004-2021 the main methodology of AI in arrhythmia changed from support vector machine (SVM) to deep neural networks (DNN) and the main content focusing on the detection of atrial fibrillation and ventricle arrhythmia and so on. We managed to provide a full spectrum of the publications in bibliometric way. We planned to deal arrhythmia problem using AI algorithms in the future.

Response to reviewer C:
Comment a: A few important publications on arrhythmia classification were missed in this paper, e.g., "ECG-based heartbeat classification for arrhythmia detection: A survey", "ECG arrhythmia classification based on optimum-path forest", "Automatic classification of heartbeats using ECG morphology and heartbeat interval features", "A patient-adapting heartbeat classifier using ECG morphology and heartbeat interval features", "Real-time patient-specific ECG classification by 1-D convolutional neural networks", and "Automatic diagnosis of the 12-lead ECG using a deep neural network". The first and the last one, specially, are important landmarks in the field of ECG classification. The first one provides a comprehensive analysis of arrhythmia classification papers over the last years using one or a few leads. The last one provides a classification system of 12lead ECG signals using the biggest ECG database until now. Therefore, besides being highly cited, they are important to the ECG classification literature.
Reply a: We re-check the analysis and made changed accordingly.
Changes in the text: Table 8 and Page 9 176-191.

Comment b: I do think "Brazil" is misrepresented in the contributions by country. The two papers mentioned in point a., for example, were published by Brazilian authors. Besides, many other arrhythmia classification papers were published by Brazilian authors, e.g., "Robust automated cardiac arrhythmia detection in ECG beat signals 41" and "Inter-patient ECG heartbeat classification with temporal VCG optimized by PSO 39". I do think the authors should re-check the contributions by country section in order to avoid that other countries are also misrepresented.
Reply b: As a matter of fact, the analysis of country contribution was mainly focused on the number of publications. We did believe brazil made great contribution in this area as well as other countries. We discussed this topic mainly in bibliometric approach which may not focus on every specific articles. But we did find articles

published by Brazilian authors with high citation after re-check and changes were made in Table 8.
Changes in the text: Table 8.

Comment c: ECG classification classes such as "bundle branch block", "myocardial infarction" and "sudden cardiac death" are not considered types of arrhythmias. I would suggest to the authors to review the use of the term arrhythmia for these classes.
Reply c: Thanks for the advice. We used “ECG signal” instead of “arrhythmia”.
Changes in the text: See page 21 line 437.

Comment d: I would also suggest to the authors to provide a deeper discussion on why there was a increase in papers published on arrhythmia classification in the recent years and provide some insights on the future of this field.
Reply d: We searched for detail technology revolution which prompted the application of machine learning in arrhythmia and found out event which could be evolution landmarks for ANN. We believed the technical development ultimately led to the increasing publication relevant in this realm.
Changes in the text: See page 13 line 269-274: In the evolution of networks, CNN architectures like ResNet became distinguished in 2015 which can better estimate the function of target with deeper neurons featured by increased nonlinearity. Since then, the application of ANN soared up with a larger and larger number of relevant publications and we can find papers associated with ANN in arrhythmia began to increase in 2017.
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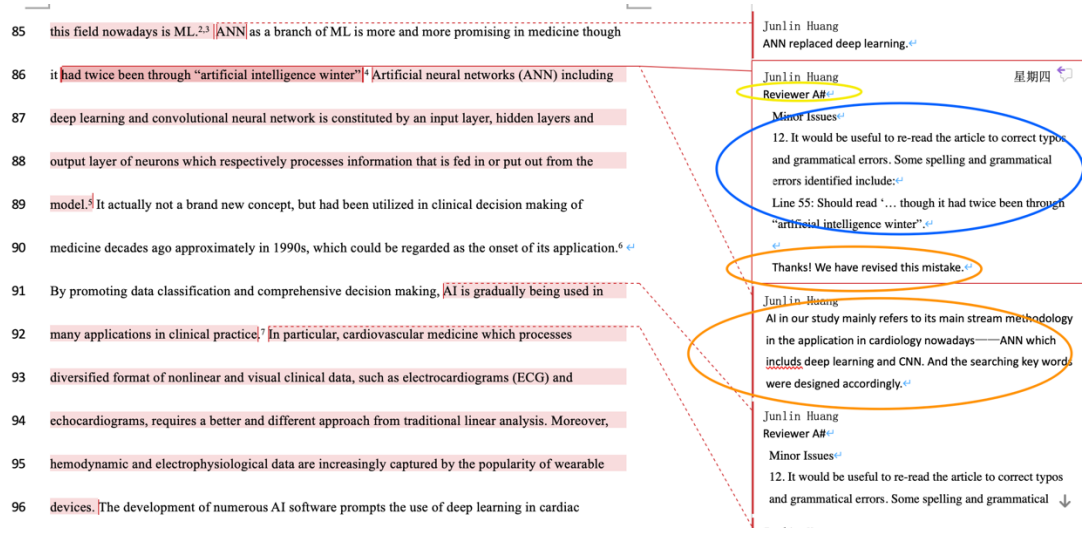
What’s more, as the picture below suggests, we added our respond in the manuscript as well which demonstrated specific reversion details with yellow circle indicating the reviewer, blue circle indicating the comment and orange circle reply in different style of words.


this field nowadays is ML.[2,3] ANN as a branch of ML is more and more promising in medicine though
it had twice been through "artificial intelligence winter".[4] Artificial neural networks (ANN) including
deep learning and convolutional neural network is constituted by an input layer, hidden layers and
output layer of neurons which respectively processes information that is fed in or put out from the
model.[5] It actually not a brand new concept, but had been utilized in clinical decision making of
medicine decades ago approximately in 1990s, which could be regarded as the onset of its application.[6]
By promoting data classification and comprehensive decision making, AI is gradually being used in
many applications in clinical practice.[7] In particular, cardiovascular medicine which processes
diversified format of nonlinear and visual clinical data, such as electrocardiograms (ECG) and
echocardiograms, requires a better and different approach from traditional linear analysis. Moreover,
hemodynamic and electrophysiological data are increasingly captured by the popularity of wearable
devices. The development of numerous AI software prompts the use of deep learning in cardiac
Junlin Huang
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Reviewer A#
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