

Key themes evolution, co-word analysis and Multiple correspondence analysis of Artificial Intelligence in Surgery

WORD LIMIT-MIN 1000 TO MAX 1500 WORDS

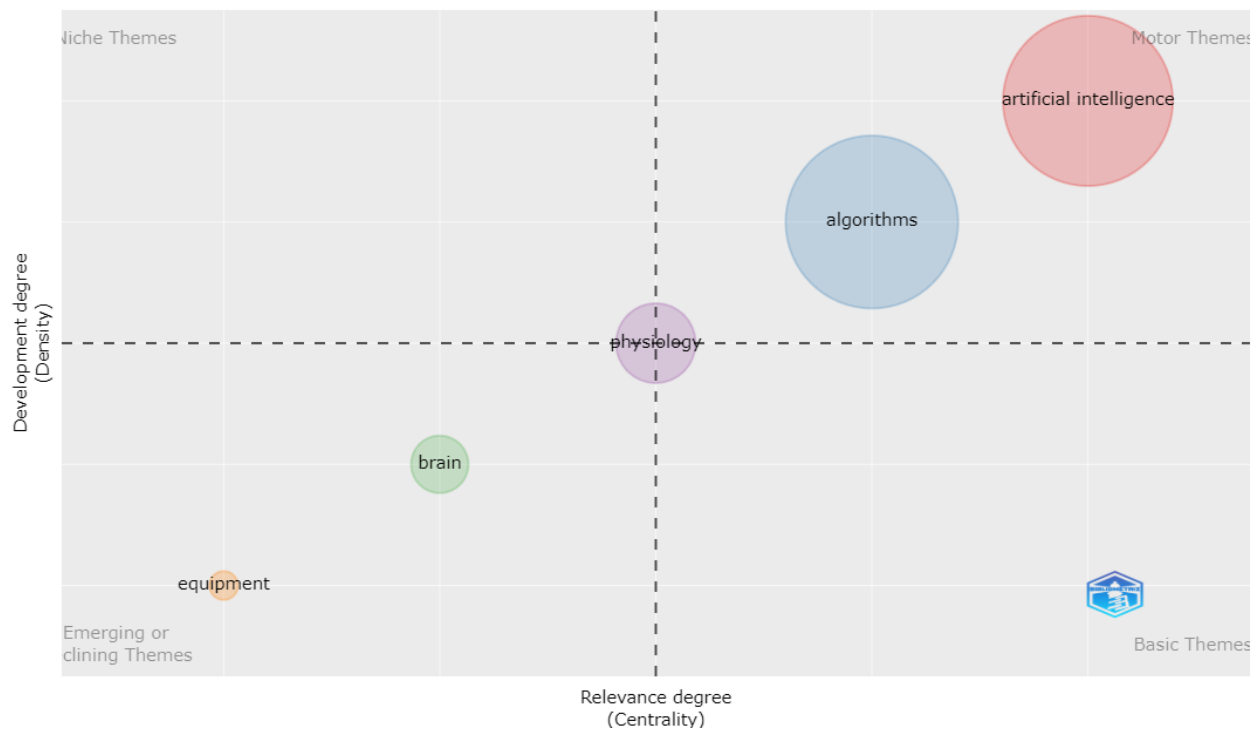
Introduction-Why this topic is important (100 -200 word)

Imagine going in surgery knowing it will succeed, no matter how complicated it is, how hard it might be, or how low the survival rate is. Artificial intelligence learns so much, more efficiently and faster than human beings. It can create links and relations between what seems unrelated. Imagine feeding it countless data on why surgeries failed and succeeded. Imagine a robot doing surgeries knowing why all previous surgeries that were done by humans (initially) failed and succeeded. Imagine a robot with the learning capabilities mentioned above. How many more lives would be saved? How many more surgeries would succeed? Imagine the percentage of surgery success skyrocketing and that of failed surgeries plummet.

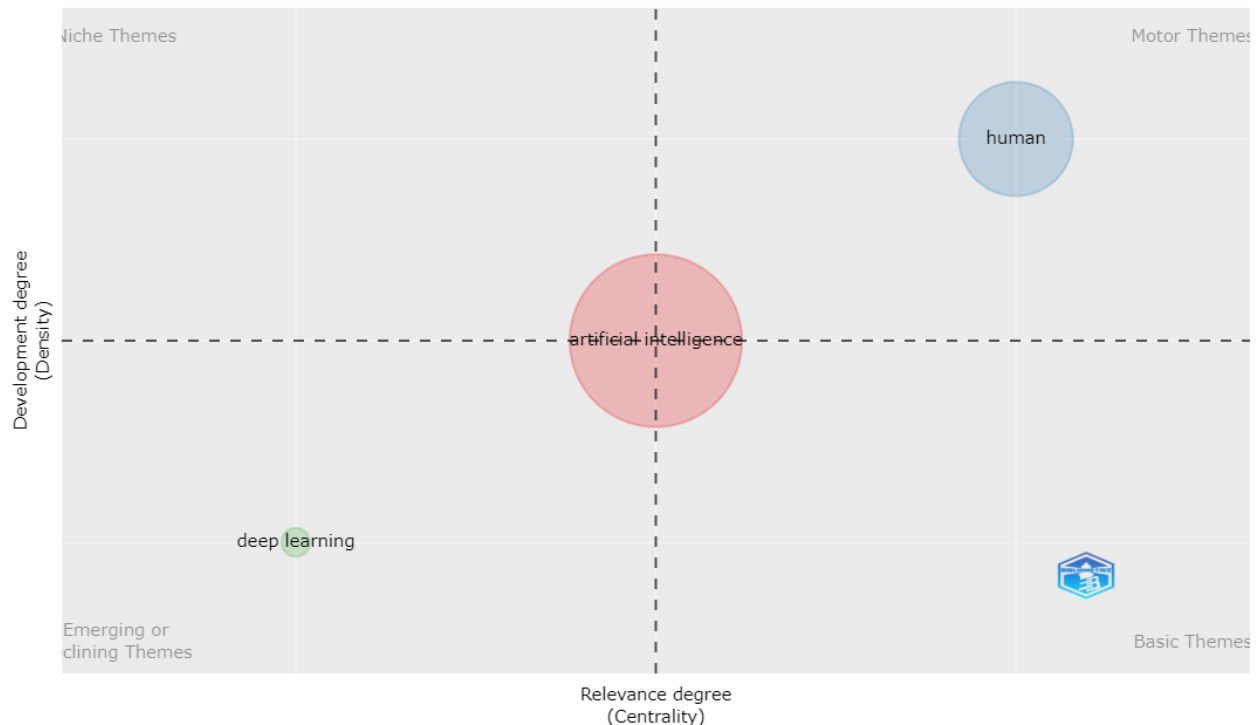
KEYWORDS USED- Bibliographic records were downloaded for the period 1988–2022 based on the presence of keywords in the title, abstract or keyword list with each article, such as artificial intelligence, data mining, surgical data science, machine learning, deep learning, surgery, decision support systems, computer-assisted surgery, virtual reality, neural networks, and robotic surgery. A total of 921 articles were obtained in this way.

OUTPUT DIAGRAM

Strategic diagram for the period 1988–2014 (410)



Strategic diagram for the period 2014–2022 (550)



Content and science mapping analyses

We use R to analyze the topics and thematic areas of the 921 papers included in this study. The initial content analysis counted 7,138 words (keywords plus) or phrases extracted by the software. These were subsequently evaluated and standardized. For instance, phrases like “laparoscopy” and “laparoscopic surgery” are judged to be the same construct. Next, we will describe the themes, strategic diagrams and cluster networks for each period.

The emerging period (1988–2014) (300-400 WORDS)

In total, 5 major themes emerge from the analysis which are artificial intelligence, algorithms, physiology, brain, with the largest ones being artificial intelligence and algorithms. The emerging or clinging themes are equipment, brain, and physiology. The motor themes are physiology, algorithms, and artificial intelligence. Physiology was all four themes – niche, basic, motor, and emerging themes. When looking at motor themes it is easy to infer that artificial intelligence was the main motor theme, as indicated by the performance measures, with 391 published papers.

As can be seen from its cluster network, artificial intelligence has been studied from different perspectives: surgery, computer simulation, medical computing, robotics, virtual reality, user-computer interface, and many more different perspectives. While looking at artificial intelligence, in this period, we can see that it has been not only mentioned in, but also influenced numerous articles and published papers about the previously mentioned perspectives. This enabled artificial intelligence to be the main motor theme, from 1988 to 2014. Artificial intelligence leverages computers and machines to mimic the problem-solving and decision-making capabilities of the human mind. It allows them to work and solve problems efficiently.

As stated above, algorithms was another motor theme. It had 196 published papers. Algorithms was studied from different perspectives: reproducibility of results, computer-assisted diagnosis, computer assisted surgery, radiology, and more perspectives, which algorithms influenced as well. Algorithm refers to a method or a mathematical process for problem-solving. It determines how fast a problem can be solved. It is very beneficial as it is the model a machine uses to solve the surgical problem.

Physiology had 12 published papers. It was studied from different perspectives from different fields: animals (focus being on swine) electrocardiography, orthopedic surgery, biopsy, robotic arms, movement, and more. Physiology is the branch of biology that deals with the normal functions of living organisms and their parts. It is essential, in this case, because we are trying to use AI in surgery.

As for the emerging themes, brain was the main emerging theme, with 21 published papers. Physiology comes after. Lastly, equipment comes, with 10 published papers. Brain has been studied from various perspectives: brain, neurosurgery, deep brain stimulation, brain depth stimulation, and data processing. This is essential to know because of neurosurgery. Equipment was studied from different perspectives: equipment, implants (surgical), and equipment failure analysis. Equipment will be beneficial because they’ll be used for implants and the needed machinery for surgery.

The expansion period (2014–2022) (300-400 WORDS)

Research in this period indicates that artificial intelligence and human stand out as major research topics. Artificial intelligence continues to be a main motor theme. Moreover, it also becomes a basic, emerging, and niche theme, which means there has been a breakthrough in artificial intelligence, and we now have a basis that we can build upon. In this period, artificial intelligence achieved a total of 385 published papers. Looking at its cluster diagram for this period, we can see the other research topics it is linked to, for instance, surgery, diagnosis, robotics, medical imaging, robots, automation, and countless more topics.

Human is another important motor theme, with 90 published papers. Looking at its cluster diagram, we can see the other research topics it is linked to, for instance, blood, blood vessels, cancer surgery, liver, and more various topics. The human theme can be seen as the evolution of the physiology theme from the previous period, which presents a stronger link to the first topic.

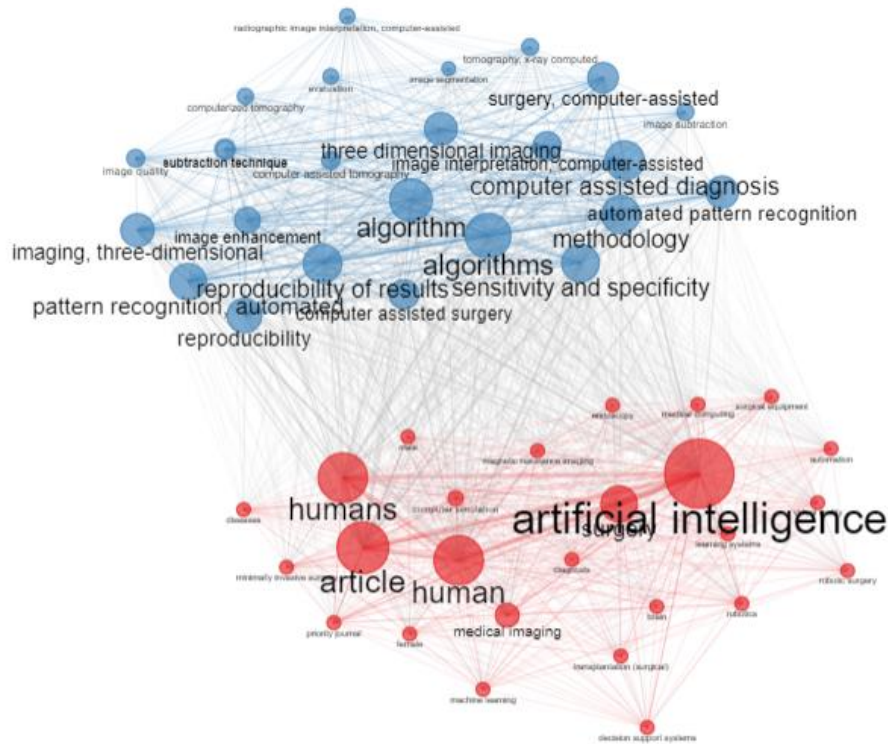
Other themes in this period are emerging, niche, and basic themes. Emerging themes in this period are artificial intelligence and deep learning. Niche and basic themes are artificial intelligence.

Focusing on the emerging themes in this period, deep learning has a total of 39 published papers. We can see, from its cluster diagram, that deep learning has been linked to other research topics, such as, decision trees, tissues, tumors, neural networks, brain, biomechanics, bone, biological organs, chemotherapy, classification accuracy, electrophysiology, and more topics. The deep learning theme can be seen as the evolution of the algorithm and brain themes from the previous period. Deep Learning is a subfield of machine learning concerned with algorithms inspired by the structure and function of the brain. It is very beneficial because it is what will be used by the machines to learn about different surgeries, the reasons they failed, and the reasons they succeeded.

On one hand, looking at artificial intelligence from the basic theme perspective, we can see that AI is central to this field of research, but it is underdeveloped. On the other hand, looking at artificial intelligence from the niche theme, we understand that AI is characterized by high internal cohesion and a relatively low degree of interaction with other topics.

OUTPUT

01 COWORD ANALYSIS FOR Artificial Intelligence in Surgery



Cluster (items)	Keywords on R
Red (26)	artificial intelligence, surgery, human, article humans, robotics, computer simulation, medical imaging, learning systems, diagnosis, decision support systems, magnetic resonance imaging, priority journal, surgical equipment, machine learning, diseases, minimally invasive surgery, transplantation (surgical), female, male, brain, endoscopy, virtual reality, robotic surgery, medical computing, automation
Blue (24)	sensitivity and specificity, algorithms, algorithm, image enhancement, computer assisted diagnosis, methodology, reproducibility of results, (pattern recognition, automated), computer assisted surgery, reproducibility, (imaging, three-dimensional), three dimensional imaging, (surgery, computer-assisted), automated pattern recognition, (image interpretation, computer-assisted), computerized tomography, computer assisted tomography, image segmentation, image quality, subtraction technique, (tomography, x-ray computed), image subtraction, evaluation, (radiographic image interpretation, computer-assisted)

EXPLANATION (MIN 400 WORDS)

The red cluster presents studies on artificial intelligence and the ability to use it in surgery with all its various branches. Artificial intelligence in surgery has been studied from different relevant perspectives, such as robotic surgery and medical computing. As mentioned before, AI will be vital in surgery. Artificial Intelligence along with robotic surgery will allow robots / machines to perform very complex surgeries with extreme precision and control. In Robotics in Neurosurgery – Past, Presence and Future, “neurosurgery is the perfect field for the implementation of robotic assisted procedures. Neurosurgical operations require precise and fine manipulation of deeply located critical neural structures that are accessed through a small corridor.” (Tomasz O. et al., 2021). There is no doubt that we will need algorithms which will enable the machines to solve surgical problems as fast and efficiently as possible. We will undoubtedly also need to teach AI about humans, physiology - which is the science of the normal functions of living organisms and their parts –, and human physiology. In BATS: A Blockchain and AI-Empowered Drone-Assisted Telesurgery System towards 6G “Artificial Intelligence has great potential in diverse real-time mission-critical applications and one such application is telesurgery or robotic surgery.” (Gupta R. et al., 2021).

Since AI will need always need algorithms regardless of the field, there has been numerous studies on algorithms and how we can use them to enable artificial intelligence to solve problems related to surgery as fast and efficiently as possible. These studies are presented by the blue cluster. Algorithms has been studied from different perspectives, such as computer-assisted diagnosis and automated pattern recognition. Algorithms, tomography, and automated pattern recognition will play a vital role in allowing AI to perform different surgeries from different branches very efficiently, precisely, and with great control. In Computer Methods in Biomechanics and Biomedical Engineering: Imaging and Visualization “Surgical robots rely on robust and efficient computer vision algorithms to be able to intervene in real-time... training of such algorithms requires large endoscopic datasets which are challenging to obtain.” (Cartucho J. et al., 2021). There have been many experiments done on the effects and usefulness of algorithms on helping patients during the many stages and phases of their journeys. In Whole Slide Imaging (WSI) in Pathology: Current Perspectives and Future Directions, “Whole slide imaging (WSI) has been validated for a number of applications in the field of pathology. The recent approval of US FDA to a WSI system for use in primary surgical pathology diagnosis has opened

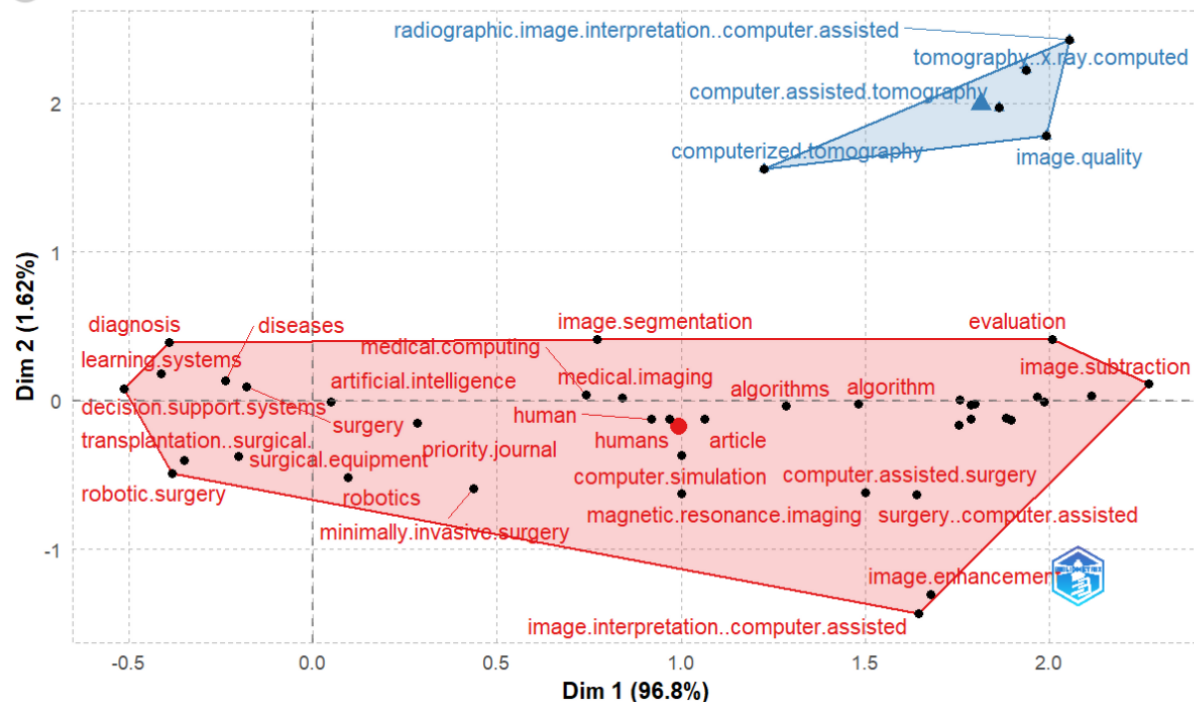
avenues for wider acceptance and application of this technology in routine practice. The ongoing technological advances in digital scanners, image visualization methods, and the integration of artificial intelligence-derived algorithms with these systems provide opportunities of its newer applications. Its benefits are innumerable such as ease of access through internet, avoidance of physical storage space, and no risk of deterioration of staining quality or breakage of slides to name a few.” (Kumar N. et al., 2020). These advancements will lead to other more complex surgical procedures because of the FDA approval.

MULTIPLE CORRESPONDENCE ANALYSIS

EXPLANATION OF CLUSTERS JUST LIKE ABOVE BUT USING THE ARTICLES THAT ARE CONTRIBUTING TO EACH CLUSTER (200 WORDS)



Conceptual Structure Map - method: MCA



By looking at the red cluster, we can tell that it is focused on artificial intelligence, surgery, and everything in between. Here we can tell that magnetic resonance imaging was one of the studied topics that are related to artificial intelligence. According to An imageomics and multi-network based deep learning model for risk assessment of liver transplantation for hepatocellular cancer, this was very useful when AI that uses magnetic resonance imaging was developed to assess risks better regarding liver transplants. (He T. et al., 2021)

By looking at the blue cluster, we can tell that it is focused on tomography – with all its different branches – and image quality. Tomography is imaging by sections through the use of any kind of penetrating wave. Therefore, tomography is used in radiology and many other science fields. According to Real-time retinal layer segmentation of adaptive optics optical coherence tomography angiography with deep learning, “Real time rendering of en face optical coherence tomography (OCT) and OCT-angiography (OCTA) of arbitrary retinal layers in ophthalmic imaging sessions can be used to increase the yield rate of high-quality acquisitions, provide real-time feedback during image-guided surgeries and compensate aberrations in sensorless adaptive optics (AO) OCT and OCTA.” (Jian Y. et al., 2020)