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Leveraging AI in Infrared Medical Imaging

Supporting the early diagnosis of illness, injury, or infection

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Abstract

Artificial intelligence is poised to radically change the way you and your physician assess your health status, but perhaps not in the way you imagined. The temperature patterns present in the surface of your skin can reveal the presence of and anatomical location of illness, injury, and infection. Historically, temperature assessment has been conducted using a single-point temperature from the forehead. As with any science, a single data point is often limited in its ability to inform. With rare exception, we find that there is greater insight when we examine a comprehensive set of data, the relationship of the data points, and the changes expressed in the data over time. Perhaps not at your next doctor's visit, but not too long thereafter, your physician will seek to understand the temperature patterns operating across your body as a more comprehensive indicator of health status. AI will make possible richer insights and revelations into health status by equipping physicians and clinicians with both a real-time and longitudinal lens into the vast temperature landscape operating across the body.

Introduction

The practice of assessing patterns in temperature distribution across the human body dates to the father of medicine, Hippocrates (400 B.C.). Hippocrates was known to cover the patient's thorax with an earth-soaked, mud cloth. For Hippocrates, the patterns of dry areas that emerged revealed the temperature distribution across the patient's body. For Hippocrates, this was MI, or "mud intelligence".

"In whatever part of the body excess heat or cold is felt, the disease is there to be discovered." - Hippocrates[1]

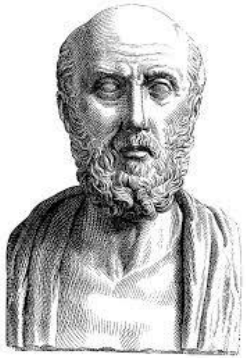


Figure 1. Hippocrates

Infrared Medical Imaging (IMI) or Thermology is a diagnostic tool utilized by a broad cross-section of specialties in medicine to assist in the early diagnosis of disease, injury, and/ or infection. Assessing the

temperature patterns in the body can serve as a quantitative measure of a number of bodily processes that result in increasing or decreasing skin temperature.[2] In the United States, IMI has received very limited adoption to date. There are a number of reasons as to why this is the case, including:

- A lack of attention to the IMI in our country's medical schools,
- The lack of reimbursement for IMI, which in an environment where "payment determines the protocol" can suffocate adoption of emerging technologies, and
- The productivity demands on primary care and specialty physicians which require many physicians to conduct a full assessment within a seven-minute visit window with the patient.

With that said, there are powerful forces operating across the healthcare delivery landscape that will contribute to the accelerated adoption of IMI in the months and years ahead. These forces include:

- The rise of and need for regenerative medicine to address degenerative conditions (such as osteoarthritis) common with the aging of the U.S. population.
- The increased prevalence of concierge medicine as a response to an increasingly larger number of patients demanding a deeper dialogue and richer experience with their physician.
- The immeasurable value of understanding the inflammatory processes operating across the body due to the fundamental role inflammation plays in the disease process for musculoskeletal disorders, cardiovascular disease, infectious disease, neurological conditions, and oncology.

When the body is injured, undergoing an illness, or being invaded (infection), the body ignites an inflammatory response that includes vasodilation, or dilating the blood vessels so that the body can deliver its response to the injured or infected anatomical area[3]. This vasodilation and inflammatory response can create temperature change in the targeted anatomical region[4]. As an example, when you sprain your ankle, the body responds with swelling and increased temperature in the injured ankle. This is the inflammatory response the body has initiated to begin delivering nutrients to address the soft tissue injury (sprain) in the ankle. This will present as a region of concentrated heat when viewed through the lens of an infrared camera. Similarly, when responding to an infection, the body will express asymmetrical—or bilaterally diverse ranges of temperature on the right and left side of the face—patterns of skin temperature in the face, which can signal the presence of infection prior to the expression of fever. In patients with peripheral vascular disease, we will see a different finding, a decrease in temperature in the extremities of the hand and feet. This can help us to discover the body's inability to deliver blood flow or oxygen to the peripheral extremities which can be helpful in diagnosing potential diabetic foot ulcer, as one example.

The body's expression of symmetrical and asymmetrical patterns of temperature can inform physicians and clinicians of the presence of illness, injury, or infection. The patterns resulting from an infrared medical image can also provide valuable insight into the anatomical location of

the injury, which can be particularly important when physicians seek to identify the cause of a sensation of pain, which can go undetected if the clinician is limited to morphological ultrasound exams as the only complement to a physical exam. Hippocrates understood this in its most basic form. It is fair to say that Hippocrates would have been an early adopter of AI-assisted IMI. He would have been fascinated by the ability of AI-assisted IMI to reflect thermal data patterns in the human body, both at a point-in-time and longitudinally, across a wide range of anatomical regions, and for assessment of a broad range of disease and conditions. And, unlike the limited set of patterns revealed in the mud bath utilized by Hippocrates, the amount of data offered by a thermal camera can exceed 786,432 data points.

The volume of thermal data will require artificial intelligence to become a necessary complement to IMI to support the capture, isolation and evaluation of thermal patterns. More specifically, the ability of AI to complement and advance IMI in medical practice is being driven by:

The volume of thermal data points and thermal patterns produced in a full- or partial-body (focused on a specific anatomical region) IMI exam

Historically, physicians and clinicians seeking to integrate IMI have been limited to a visual assessment of the regions of interest. And, while a visual review of the image remains necessary, AI permits the automation of the full- and partial-body exams that consider a broader range of thermal data and patterns and help ensure that the clinical professional assessing the image does not fail to consider the entirety of the insight available in the image.

Technology platforms, such as Vizbodx, support the capture, storage, and evaluation of thermal images by leveraging pose estimation AI to isolate the anatomical regions to be analyzed in the infrared medical image. Use of AI in this manner can be expected to reduce human error in IMI, leading to improved diagnostic accuracy and increased workflow efficiency.

The need for real-time, one-time (as part of a physical exam), and longitudinal assessment of thermal patterns in individuals, cohorts, and populations

Assessment of thermal patterns in real-time, as part of a physical exam, and/or longitudinally will be enhanced by analyzing data patterns relative to the individual and relative to comparative norms for progression or regression of the individual's disease or condition. In this respect, AI-enabled IMI will equip clinicians to isolate the location of the injury or condition and monitor recovery relative progress over time and relative to the expected norms for the condition.

The reliance of IMI on the presentation of symmetrical and/or asymmetrical thermal patterns to distinguish or isolate the presence of a disease, injury, or infection

When analyzing the individual for a disease or injury using IMI, the body's desire for symmetry in a healthy state allows the interpreter of the infrared medical image to assess the body from a bilateral perspective to gain insights into the presence of injury or illness. As an example,

consider the patient with low-back pain who presents to the physician and undergoes an infrared medical image exam. The physician conducting the IMI exam will evaluate the image for deviations in temperature to the right or left side of the spine as an indicator of the location of the injury or condition. This deviation represents an asymmetrical temperature pattern, with the individual's body serving as the control for the evaluation.

By examining the individual relative to the expected norms for symmetrical thermal patterns, the clinician is able to consider thermal findings specific to the individual and relative to cohorts or populations, segmented by demographic or condition. Use of AI-enabled IMI in this manner will permit researchers to begin to link specific thermal patterns to a specific disease, condition, or relative condition progression.

The ability to target intervention(s) into specific anatomical regions and to monitor recovery to prescribed interventions

The ability to target interventions with greater precision into anatomical regions is particularly important in regenerative medicine where the efficacy of the intervention is a function of placement precision. The patient's response to regenerative interventions is often highly personal and can be difficult to predict. By complementing increased precision in the diagnosis phase with increased understanding of intervention efficacy in the treatment phase, AI-assisted IMI will be able to provide tremendous insights into the patient physical and psychological characteristics common to optimize intervention strategy in regenerative medicine.

And, because emerging regenerative interventions are often not covered by insurance in the early launch phase of the intervention, AI will be instrumental in optimizing the use of interventions towards those conditions. As an example, a regenerative intervention can be expected to deliver a biological response in the targeted region. This biological response can include vasodilation (i.e. ultrasound prompted vasodilation) to deliver nutrients into the targeted region. Using AI, normative thermal responses to interventions will identify the expected period of elevated heat (the response to vasodilation) and decreases in skin temperature as the body responds and the inflammatory response recedes.

By leveraging the capabilities of AI to assist in the interpretation complex thermal images, physicians, clinicians, patients, and payers stand to benefit from earlier diagnosis, increased precision in the diagnosis, improved intervention accuracy, and reduced overall cost. In healthcare, AI-assisted IMI will complement the physical exam and other diagnostic tools to deliver new, distinctive insights for physicians and clinicians to intervene earlier, more accurately, and better assess the process of recovery. This is AI as augmented intelligence.

The practical application of AI- assisted infrared imaging to assess musculoskeletal disorders

The rising incidence of musculoskeletal disorders (MSDs) among athletes, workers and the aging of the population presents a significant public health challenge and economic burden

worldwide. Musculoskeletal conditions ranging from acute injuries such as sprains and fractures to chronic conditions like arthritis and back pain, are the leading contributors to disability globally, impacting millions of individuals' quality of life and their ability to work or perform athletically.[5]

In the realm of athletics, musculoskeletal injuries are a primary concern due to the impact on performance and career longevity. The physical demands placed on athletes increase the risk of injury, which can lead to significant downtime, reduced performance, financial loss, and, in severe cases, early retirement from sports. The American Orthopaedic Society for Sports Medicine reports that there are approximately 3.5 million injuries each year just among school-aged children in the United States, underscoring the urgent need for effective preventative and diagnostic solutions in the athletic domain.

Similarly, in occupational health, musculoskeletal disorders account for a significant proportion of work-related injuries and illnesses. According to the U.S. Bureau of Labor Statistics, MSDs account for approximately 33% of all worker injury and illness cases. These conditions not only affect employee health and productivity but also impose substantial costs on employers due to lost workdays, decreased productivity, and workers' compensation claims. For instance, the direct costs of MSDs in the workplace are estimated to be as high as $20 billion annually in the United States, with total costs, including indirect costs such as lost earnings and productivity, reaching $100 billion.

The critical barriers to successfully intervening in musculoskeletal disorders include late diagnosis, misdiagnosis, and suboptimal management of these conditions[6]. Traditional diagnostic methods, such as physical examinations and standard imaging techniques like X-rays and MRI, can be time-consuming, costly, and sometimes ineffective in detecting early signs of musculoskeletal damage or disease. This delay in diagnosis often results in prolonged recovery times, increased risk of recurrence, and higher medical costs.

Moreover, the existing diagnostic processes can be invasive, expensive and uncomfortable for patients, contributing to a reluctance to seek early treatment. There is also a significant variability in diagnostic accuracy, depending largely on the clinician's experience and expertise. This inconsistency can lead to misdiagnoses, unnecessary treatments, or overlooked conditions, further exacerbating the challenges faced by athletes and workers suffering from MSDs.

Given these challenges, there is a dire need for innovative diagnostic solutions that can accurately, quickly, and non-invasively detect musculoskeletal disorders at an early stage. The integration of Artificial Intelligence (AI) with thermal imaging technology offers a promising approach to revolutionize the diagnosis and management of MSDs. By harnessing the power of AI to analyze thermal images, this advanced diagnostic tool can identify subtle physiological changes through the skin that precedes the onset of musculoskeletal conditions, facilitating timely intervention and personalized treatment plans. AI-equipped IMI has the potential to improve outcomes for athletes and employees but also to significantly reduce healthcare and societal costs associated with musculoskeletal disorders.

The researchers and software developers at Vizbodx are working to fill the gap between current state and potential in the practice of IMI. The Vizbodx platform is AI-equipped IMI to support

the analysis of thermal patterns on the skin's surface, thereby enabling physicians and clinicians to pinpoint areas of inflammation, abnormal blood flow, or other anomalies indicative of underlying musculoskeletal issues.

Integrating AI-enabled infrared imaging into medical practice

Traditional methods for diagnosing MSDs often involve time-consuming and invasive procedures that can be inconclusive, especially in cases where patients exhibit non-specific symptoms. Many individuals suffering from chronic pain or recurrent injuries have undergone multiple tests and treatments without identifying the underlying cause of their discomfort, leading to prolonged suffering and ineffective interventions. Christopher Centeno, a worldwide leader in Regenerative Medicine, shared in his book "Shoulder 2.0", that many of the significant problems we are not able to visualize in the nerves involve small fibers (Small Fiber Neuropathy), which cannot be detected reliably and consistently by electromyogram (EMG), nerve conduction study (NCS) or quantitative somatosensory tests (QST).

Using AI-powered software (Vizbodx) to capture thermal patterns and isolate abnormalities, the clinical team is able to interpret the thermal findings and diagnosis with high sensitivity in these conditions that originate in the nerves and small fibers of the body. By delivering an expedited path to earlier and more accurate diagnosis, the integration of AI-enabled infrared imaging can improve patient care while also lowering the overall cost of treatment for the patient, health systems, and healthcare payers. In their clinical practice, Dr. Leite and his clinical team led by Franciele De Meneck have conducted thousands of diagnostic exams worldwide, focusing on the early detection and management of musculoskeletal disorders (MSDs) in sports medicine and occupational health. AI-powered thermal imaging capture has enabled the Leite and De Meneck clinical team to accelerate their analysis from 20 minutes to 2 minutes, a time saving of **90%** that has improved practice workflow broadly, led to reduced costs (a savings of $518 per day and $129,600 annually in physician labor cost at $72.00 per hour), and increased patient satisfaction which has led to 20+% in year-over-year growth of the practice.

A Case Study in Sports Medicine

With athletes, Dr. Leite and his team have implemented routine screenings in high school, collegiate, and professional athletes to detect early signs of stress or injury before they become full-blown issues. As one example, a professional soccer team uses the Vizbodx platform as part of their routine fitness assessments. The AI-enabled thermal imaging platform has identified early signs of over-stress in soccer players, despite the absence of symptoms. This early detection led to preventive measures aimed at avoiding a season-ending injury.

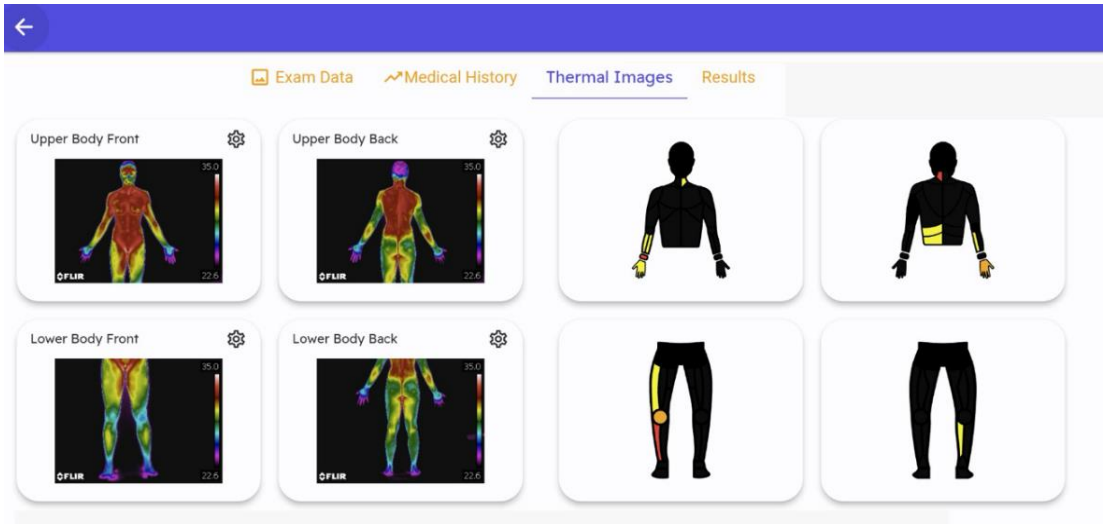
Athletes are subject to repetitive motion injuries as a result of their sport. As one example, in baseball, the pitcher as overhead athlete is subject to microtrauma in the soft tissue of the arm with each outing. This microtrauma can present itself as an inflammation in the shoulder, elbow, forearm, and wrist. Ultimately, over the course, of a season, the cumulative effects of repeated microtrauma can escalate into injury. Dr. Leite and his team are using Vizbodx to identify areas of concern in athletes prior to the expression of pain. This effort is aimed at

getting out in front of a potential injury by identifying thermal, vasomotor, and inflammatory patterns that suggest injury progression before the expression of pain. Ongoing studies are examining the longitudinal effect of microtrauma on soft tissue. The findings from these studies, enhanced by AI, will enable researchers to examine the pattern of the patterns, or the patterns of thermal expressions that are more likely associated with advancing disease or injury.

Artificial intelligence, embedded into the Vizbodx software, is enabling clinicians to assess the presence of microtrauma in targeted tissue. AI is able to 1) present the thermal data and the associated thermal patterns using "body masks" that enable the data and thermal patterns from the captured infrared image to isolate the regions of interest consistently within and across individuals and populations and 2) account for the expected deviation in temperature from the dominant side of the athlete so that the clinician is better able to isolate the body's thermal response to microtrauma. And, because the body desires symmetry with respect to its thermal patterns, the body can be assessed for bilateral symmetry and asymmetry with respect to thermal patterns.

Going forward, integrated AI will equip physicians to monitor longitudinal changes in thermal patterns to assess illness or infection progression and/or monitor the body's response to the pharmaceutical, regenerative, biomechanical, or surgical interventions. This has particular relevance to sports medicine where the goal is injury prevention and accelerated return to play following an injury. With the advanced understandings available through AI-enabled IMI, physicians and clinicians will be better able to identify a potential injury at the earlier stages, which can be extremely valuable in sports which almost always require repetitive motion and isolated stress on specific joints and tissues. In addition, using AI-powered IMI, physicians and clinicians will be able to more accurately assess the body's the response to activity during the recovery when an increased load or activity is applied to the compromised or repaired anatomical region. This will equip physicians and clinicians to determine with greater confidence if the athlete is ready to return to play.

The photo below depicts the translation of the thermal image into areas of high interest or, in this case, where there is significant bilateral asymmetry in temperature patterns.



A Case Study in Low Back Pain

A 63-year-old man presented with a complaint of low back pain that had been ongoing for ten (10) months. The patient had been to six doctors prior to his visit. The doctors had not found any degenerative abnormalities using traditional imaging tests (Discal Bulging, arthrosis, degeneration of multifidus muscle). The patient had been given non-steroidal anti-inflammatory medications (NSAIDs), corticoid intramuscular injections (3), and extensive physiotherapy for 6 months. These interventions were provided to the patient, although the root cause of the pain remained elusive.

Figure 3- Visual image of the patient

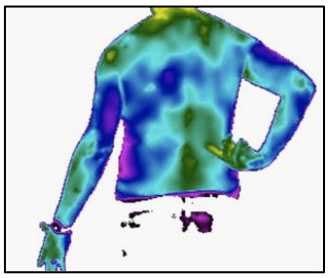


Figure 4 - Thermographic view of the patient

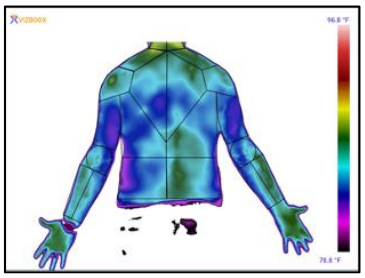


Figure 5 - Imaged processed with Vizbodx's A.I.

Upon arriving to Dr. Leite's clinic, the patient immediately underwent a full-body infrared imaging exam. The AI in the Vizbodx platform permitted Dr. Leite and his team to assess the entire body and specific regions of the body for thermal abnormalities. The AI in the software allowed the team to identify quantitatively and qualitatively the degree of asymmetrical thermal patterns in the patient's upper body. As a result of the exam, Dr. Leite and the clinical team were able to identify a subtle thermal anomaly in a region previously considered unrelated to the patient's symptoms (Myofascial Psoas Pain). The clinical team confirmed the findings using a physical exam and ultrasound. As a result of the incremental insight provided by the IMI findings, Leite and his clinical team were able to prescribe targeted treatment (Focused Electromagnetic Shockwave Therapy for 4 sessions) that ultimately resolved the patient's chronic pain without the use of medications. The patient fully recovered in eight (8) weeks.

A Case Study in Infectious Disease

During the pandemic year, there was great concern that the elderly would be particularly vulnerable to Covid-19 given the compromised immune systems common to older adults. And, with any infectious disease, the greatest amount of viral shedding in infected individuals begins 3 days prior to fever expression. This can render point temperature checks of the forehead…pointless. By the time fever is discovered, it is too late as the infected individual has very likely been in contact with individuals during the aggressive viral shedding period that

occurs prior to fever. This reality in infectious disease can be particularly problematic in high-risk settings, such as senior care facilities.

To address this concern, software programs such as FeverFy (Brazil) and Viral Sign (USA) were able to leverage the power of IMI to screen individuals for the presence of virus before the presentation of fever[7]. These software programs incorporated an Artificial Intelligence algorithm using Convolutional Neural Networks (CNN) to identify COVID infected people prior to the expression of fever. According to this study, the incidence of people infected with COVID that did not present with a fever was about 89.5%. As a result, assessments of temperature using single- or point-temperature approaches would fail to detect the presence of virus during its robust viral shedding phase.

Figure 6- People waiting in line for Viral Sign evaluation in India

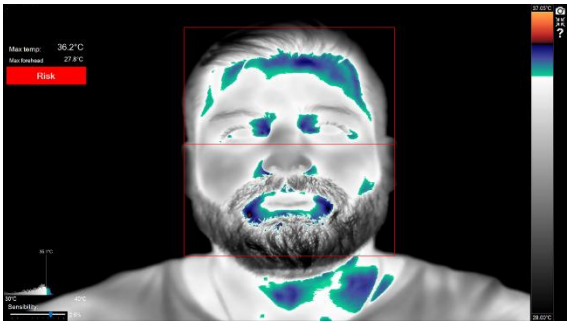


Figure 7 – Example of a FeverFy result detecting the presence of virus in the absence of fever

These software programs enabled caregivers in senior care settings and at industrial sites to protect their populations by discovering the suspicion of virus prior to fever expression, and prior to the individual suspected of carrying the virus was exposed to other residents, clinicians, and co-workers. Again, this work borrowed from the principles of temperature expression in the body from 2,500 years ago. The body, when healthy, will transmit temperature patterns in the face that are bilaterally symmetrical. When unhealthy or defending itself from an invader (a virus), the temperature patters in the face will begin to express an asymmetrical pattern. Early detection of the presence of virus, during the incubation, intensive viral shedding period, made possible with AI-enabled IMI will continue to mitigate infection transmission and save lives.

The Impact of AI-enabled infrared imaging

AI is working to advancing the IMI diagnostic process by enabling the capture and interpretation of thermal patterns presenting on the skin's surface. Subtle changes in temperature at a specific location or locations on the body, that previously may have been overlooked by the human eye or ignored as a result of the vast amount of thermal data captured during an IMI exam, can now be isolated and presented for further investigation and

interpretation by trained clinicians in the practice of IMI. This is bringing increased confidence in IMI findings to physicians.

As Hippocrates understood, the body's thermal patterns are capable of delivering significant insights into the location of an illness, injury, or infection. AI is helping us to listen more closely to the body's expression of its symmetrical or asymmetrical thermal patterns. This will deliver a future in medicine whereby clinicians are better able to isolate the location of the cause of the condition, but also assess the value of interventions in delaying a disease process or arresting the progression of a degenerative disease such as osteoarthritis.

AI is also contributing to improved workflow with respect to IMI inside the practice of the physician and/or clinician. Expediting the process to IMI findings, a result of using AI to quickly capture and present outlier thermal findings, is enabling clinicians to review findings while the patient remains in the physician's practice. Ultimately, by enabling earlier, more accurate diagnosis at the early in the onset of disease, condition, or injury progression, AI-enabled IMI will enhance individual patient care in the near- and long-term.

Going forward, the power of AI will bring new understandings of the power of thermal patterns to assess, isolate, and monitor individuals, patient cohorts, and populations. The clinical and development teams at Vizbodx will create a registry of thermal images paired with their findings which will enable an incremental AI layer to permit clinicians and their colleagues in IMI to associate thermal patterns with specific conditions. The use of AI as a complement to IMI is expected to create greater demand for the integration of thermal findings into the diagnostic work-up of the patient, complementing the physical examination and other diagnostic tools. Integrating AI-assisted IMI into the diagnostic workflow in the clinic promises to bring increased precision to the diagnostic process across a range of conditions, including musculoskeletal, neurological, cardiovascular, diabetes, and cancer. Using AI, the integration of structured and unstructured insights from the patient's history, the thermal findings, and the ultimate diagnosis will deliver increased precision to the diagnostic process, health status, and the efficacy of interventions, including surgical, biological, biomechanical, and pharmaceutical.

Twenty-five hundred (2,500) years after the discovery of the power of thermal patterns using "mud intelligence" by Hippocrates, we find ourselves on the cusp of an era in IMI that will leverage AI to transform the efficacy and efficiency of the diagnostic process for musculoskeletal, vascular disease, infectious disease, and neurological conditions. In the months ahead, AI assistance to IMI will ensure that we increasingly hear, "The doctor will see your infrared medical image now."

About the Authors

Barry Hix is the Chief Executive Officer for Vizbodx, Inc., a Delaware corporation founded in 2023 to bring AI-enabled infrared medical imaging to sports medicine, occupational medicine, and senior care. Barry also serves as a commercial advisor to domestic and international MedTech and Life Science organizations and brand teams seeking to establish presence and accelerate adoption in U.S. markets.

Mayco Moreira serves as the Chief Technology Officer at Vizbodx Inc., where he leads the development and integration of computer-aided thermographic exams. With a solid foundation as a software developer at prestigious firms including IBM, he possesses extensive expertise in deploying artificial intelligence technologies across multiple sectors such as healthcare, finance, and education. Mayco has over six years of experience in computer-aided infrared technologies and his innovations have impacted more than 5 million of evaluations in 20 countries.

Dr. Joao Paulo B. Leite is a global thought leader, researcher, and practitioner in interventional orthopedics, regenerative medicine, neurophysiology, and thermography. At the BioPain Institute in Brazil, Dr. Leite has pioneered the use of infrared medical imaging early in the patient care process, which has led to his work being recognized for individualized, patient-focused care protocols that accelerate recovery and safely return patients to activity. In addition to his work at the BioPain Institute and in academia, Dr. Leite serves as the chief medical officer for Vizbodx, Inc.

Franciele de Meneck, PhD is a Doctor of Physiotherapy with 16 publications and 119 citations for research in the field of infrared medical imaging, or thermography. Her published work has led to advancing the use of thermography in orthopedics, sports medicine, general surgery, infectious disease, cardiology, and pediatrics. The depth and breadth of her work in research and with patients has made Fran a valued colleague to physicians and clinicians around the world. At the BioPain Institute in São Paulo Brazil, Dr. de Meneck has teamed with Dr. Leite for the past ten years to treat patients with complex conditions in sports medicine, occupational medicine, and neurological-based conditions. Dr. de Meneck provides clinical support to Vizbodx and Vizbodx clients on the use of thermography in medical practice.

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About the Journal

The Journal of Business and Artificial Intelligence (ISSN: 2995-5971) is the leading publication at the nexus of artificial intelligence (AI) and business practices. Our primary goal is to serve as a premier forum for the dissemination of practical, case-study-based insights into how AI can be effectively applied to various business problems. The journal focuses on a wide array of topics, including product development, market research, discovery, sales & marketing, compliance, and manufacturing & supply chain. By providing in-depth analyses and showcasing innovative

applications of AI, we seek to guide businesses in harnessing AI's potential to optimize their operations and strategies.

In addition to these areas, the journal places a significant emphasis on how AI can aid in scaling organizations, enhancing revenue growth, financial forecasting, and all facets of sales, sales operations, and business operations. We cater to a diverse readership that ranges from AI professionals and business executives to academic researchers and policymakers. By presenting well-researched case studies and empirical data, The Journal of Business and Artificial Intelligence is an invaluable resource that not only informs but also inspires new, transformative approaches in the rapidly evolving landscape of business and technology. Our overarching aim is to bridge the gap between theoretical AI advancements and their practical, profitable applications in the business world.

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