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OF INVENTORSHIP AND PATENT OWNERSHIP: EXAMINING THE INTERSECTION BETWEEN ARTIFICIAL INTELLIGENCE AND PATENT LAW

Cheng Lim **Saw**[*] and Samuel Zheng Wen **Chan**[**]

Artificial intelligence ("AI") has garnered much attention in recent years, with capabilities spanning the operation of self-driving cars to the emulation of the great artistic masters of old. The field has now been ostensibly enlarged in light of the professed abilities of AI machines to autonomously generate patentable inventions. This article examines the present state of AI technology and the suitability of existing patent law frameworks in accommodating it. Looking ahead, the authors also offer two recommendations in a bid to anticipate and resolve the challenges that future developments in AI technology might pose to patent law. In particular, the case is made for fully autonomous machine inventors to be recognised as "inventors" by statute and for patent ownership of AI-generated inventions to be granted to the owners of these machine inventors by default.

I. Introduction

Humankind has long been fascinated with the prospect of intelligent humanoids.[1] This wealth of intrigue has inspired individuals – from prolific science-fiction authors[2] to ardent mathematicians[3] – to push the boundaries of artificial intelligence ("AI") through their creativity and research. These incremental developments in AI technology over the years have not escaped the watchful eyes of brooding patent lawyers who warn that questions relating to, *inter alia*, the appropriate scope of inventorship as well as the allocation of ownership of any corresponding patent rights will need to be addressed, sooner rather than later,[4] where fully autonomous machine inventors are concerned.[5] Until quite recently, these issues have remained

[*] LLB (Hons) (NUS), LLM (Cambridge). Associate Professor, Yong Pung How School of Law, Singapore Management University.

[**] LLB (summa cum laude) (SMU). This article is written in the author's personal capacity, and the opinions expressed in this article are entirely the author's own views.

1 See *eg*, Samuel Butler, *Erewhon* (1872), a novel which explores the idea of machine consciousness; Karel Čapek, *Rossumovi Univerzální Roboti* (1920), a Czech science-fiction play which imagines the rise of the robots.

2 See *eg*, William Gibson, *Idoru* (Viking Press, 1996).

3 See *eg*, Bruce Collier & James MacLachlan, *Charles Babbage: And the Engines of Perfection* (Oxford University Press, 1999) at 81–91, where the authors discuss Babbage's early contributions to automation.

4 The courts have also echoed this sentiment – see *eg*, *Commissioner of Patents v Thaler* [2022] FCAFC 62 at [119]–[120].

5 Ryan Abbott, "I Think, Therefore I Invent: Creative Computers and the Future of Patent Law" (2016) 57 BCL Rev 1079 at 1080–1081 [Abbott, "I Think, Therefore I Invent"]; Susan Tull & Paula Miller,

little more than intellectually curious and stimulating thought experiments, for the very reason that the conception of such fully autonomous entities was widely viewed as a distant (and highly improbable) possibility.[6]

However, burgeoning advancements in the field of AI within the last decade or so have vastly improved the odds,[7] thereby compelling lawmakers, judiciaries, and intellectual property offices around the world to confront these difficult questions head-on. This has triggered an exigent search for coherent and sensible legal/regulatory frameworks to deal with potential patent-related issues before (and if need be, when) they arise, as demonstrated by the consultation processes launched not only by the World Intellectual Property Organisation but also by the intellectual property offices in various countries.[8] In short, the age of the machines is nigh, and patent law is scrambling to embrace it (or so it seems).

This article seeks to contribute to the ongoing discourse by examining the adequacy of existing patent law frameworks (in particular the relevant aspects pertaining to inventorship and patent ownership) in accommodating present and future developments in AI. While the article concludes that these frameworks are technically sufficient to deal with the *present* state of AI technology, the authors argue that effecting amendments to patent legislation is clearly warranted (indeed imperative) to prevent existing regimes from being caught on the wrong foot by the *future* growth in AI capabilities. Specifically, the authors submit that the status of inventorship should, in time to come, be accorded to fully autonomous AI machines/systems, and patent ownership be granted to the owners of these machine inventors by default. It is hoped that these recommendations will provide a pragmatic yet doctrinally sound basis upon which the longstanding objectives of patent law may endure and thrive, notwithstanding the looming arrival of AI inventors.

II. Developments in Artificial Intelligence and Current Legislative Frameworks in Patent Law

A. *AI Technology: the State of the Art*

This section begins with a summary of the present state of technology pertaining to AI. The field of AI has, in recent years, witnessed significant advances in

"Patenting Artificial Intelligence: Issues of Obviousness, Inventorship, and Patent Eligibility" (2018) 1 The Journal of Robotics, Artificial Intelligence and Law 313 at 317–319.

6 See *eg*, Pamela Samuelson, "AI Authorship" (2020) 63(7) Communications of the ACM 20 at 20, where the author describes related issues pertaining to copyright as a "toy problem" because "no commercially significant outputs of AI or other software programs had yet been generated".

7 Michael Schuster, "Artificial Intelligence and Patent Ownership" (2018) 75(4) Wash & Lee L Rev 1945 at 1947 [Schuster, "Artificial Intelligence and Patent Ownership"].

8 World Intellectual Property Organisation ("WIPO"), "Draft Issues Paper on Intellectual Property Policy and Artificial Intelligence" <https://www.wipo.int/meetings/en/doc_details.jsp?doc_id=470053>; UK Intellectual Property Office ("UKIPO"), "Artificial Intelligence and Intellectual Property: Copyright and Patents" <https://www.gov.uk/government/consultations/artificial-intelligence-and-ip-copyright-and-patents/artificial-intelligence-and-intellectual-property-copyright-and-patents> (29 October 2021) [UKIPO, "Artificial Intelligence and Intellectual Property", 29 October 2021]; US Patent and Trademark Office ("USPTO"), "Request for Comments on Patenting Artificial Intelligence Inventions" <https://www.federalregister.gov/documents/2019/08/27/2019-18443/request-for-comments-on-patenting-artificial-intelligence-inventions>.

conception and application.[9] In turn, society as a whole has benefited in myriad ways, for instance through having safer autonomous vehicles[10] and more effective pharmaceutical research.[11] Nevertheless, given the slew of intricacies surrounding AI technology and that vague buzzwords such as "autonomous" and "deep learning" have proliferated in the media in recent times, it might be beneficial to elucidate and pinpoint some of AI's current capabilities right at the outset. This short introduction will hopefully aid in understanding the degree of human involvement in the conception of patentable inventions by AI entities, as well as determining whether existing patent law frameworks are suitably equipped to accommodate the current state of AI technology.

As a starting point, AI is generally considered to be a discipline of computer science targeted at creating machines and systems capable of carrying out tasks deemed to require human intelligence.[12] In other words, AI seeks (or has historically sought) to simulate complex human functions.[13] One major approach in this field has been the utilisation of "machine learning". Machine learning refers to computer programs which are the subject of learning algorithms.[14] This means that these programs are able to learn from experience for some class of tasks and improve their performance in those tasks over time.[15] To do so, the machine will require datasets in order to "train" and for its parameters to be adjusted accordingly.[16] Such AI technology has been applied in fields ranging from robotics[17] to medicine.[18]

Within this field of machine learning, the sub-field of "deep learning" has garnered much attention in recent years. Deep learning mimics the human brain's functionality through a technique termed "artificial neural networks". The development of this technique is perhaps unsurprising, given that AI scientists have long been inspired and influenced by the analogy between computers and human brains.[19] In particular, these neural networks process data using computing units (called neurons) which are arranged in ordered sections (called layers).[20] Data is then transmitted between these neurons and across the different layers in various ways.

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9 See *eg*, James Crowder, Shelli Friess & John Carbone, "Anytime Learning: A Step Toward Life-Long AI Machine Learning" in Hamid Arabnia, David de la Fuente, Elena Kozerenko, Jose Olivas & Fernando Tinetti, *International Conference on Artificial Intelligence 2019* (Providence: CSREA Press, 2019) at 16–20.

10 Imma Martinez, "Second Home" in Imma Martinez, *The Future of the Automotive Industry: The Disruptive Forces of AI, Data Analytics, and Digitization* (New York: Apress, 2021) at 98.

11 See *Thaler v Commissioner of Patents* [2021] FCA 879 at [45]–[55].

12 Stuart Russell & Peter Norvig, *Artificial Intelligence: A Modern Approach*, 3d ed (London: Pearson, 2010) at 1–2.

13 See, generally, Daniel Levine, "Theory of the Brain and Mind—Visions and History" in Robert Kozma, Cesare Alippi, Yoonsuck Choe & Francesco Carlo Morabito, *Artificial Intelligence in the Age of Neural Networks and Brain Computing* (Academic Press, 2019).

14 Zhou Zhi-Hua, *Machine Learning* (New York: Springer, 2021) at 2 [Zhou, *Machine Learning*].

15 Ryszard Michalski, Jaime Carbonell & Tom Mitchell, *Machine Learning: An Artificial Intelligence Approach* (Springer, 1983) at 3–6.

16 Zhou, *Machine Learning*, *supra* note 14 at 3.

17 See *eg*, Kim Daekyum, *et al*., "Review of machine learning in soft robotics" (2021) 16(2) PLoS ONE.

18 See *eg*, Alvin Rajkomar, Jeffrey Dean & Isaac Kohane, "Machine Learning in Medicine" (2019) 380(14) The New England Journal of Medicine 1347 at 1348–1354.

19 Daniel Levine, *Introduction to Neural and Cognitive Modeling* 3d ed (Milton Park: Routledge, 2018) at 10–17.

20 Zhou, *Machine Learning*, supra note 14 at 2; John Mueller & Luca Massaron, *Deep Learning for Dummies* (New Jersey: John Wiley & Sons, 2019) at ch 1.

Sustained "training" using datasets allows the machine to optimise the way in which data is transmitted in order to achieve desirable results. The term "deep" thus refers to the large number of layers within a machine's architecture. In simple terms, deep learning processes can be viewed as a complex mathematical function. The machine is fed some input which is processed through its many layers and subsequently produces some output. By interacting with datasets, these machines are able to utilise a feedback system to optimise its model, thereby eventually producing accurate and desirable outputs.

However, while deep learning solutions have undoubtedly led to impressive feats, the centrality of human input within these systems has certainly not diminished. For example, humans are still needed to first write the algorithms underlying the neural networks and input the relevant "training" data into the AI machine. In doing so, humans invariably define the problem or objective for the machine, as well as the methods the machine will use in its "training".[21] A machine's objective can range from the specific (for instance, accurate speech or facial recognition capabilities), to the general (such as searching for new applications for existing drugs).[22] Ultimately, the operation and output of the machine will largely depend on its architecture and the datasets it has been "trained" on – decisions which are made, at least initially, by humans. As such, the prevailing view is that AI systems and entities (such as artificial neural networks) generally serve as problem-solving or research *tools* which *assist* humans with particular functions in their research and development ("R&D") work.[23]

B. *The Unsuitability of Regarding Current AI Entities as Inventors in Patent Law*

Given this understanding of AI technology, the question in patent law for present purposes is whether such entities can be considered "inventors" if they manage to produce outputs which qualify as patentable inventions. An "inventor" is defined as "the actual deviser of the invention",[24] or the natural person who has formulated or contributed to the formulation of the inventive concept.[25] It is submitted that humans should, at present, still be regarded as the inventors of such outputs because

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21 See *eg*, Geoffrey Hinton & Ruslan Salakhutdinov, "Reducing the Dimensionality of Data with Neural Networks" (2006) 313 Science 504 at 504–505, where the authors consider methods of initialising the weights accorded to neurons within the neural network in order to optimise the machine's output.

22 See *Thaler v Commissioner of Patents*, *supra* note 11 at [48].

23 See UKIPO, "Government response to call for views on artificial intelligence and intellectual property" <https://www.gov.uk/government/consultations/artificial-intelligence-and-intellectual-property-call-for-views/government-response-to-call-for-views-on-artificial-intelligence-and-intellectual-property#ai-as-an-inventor> (23 March 2021); Daniel Seng & Tan Cheng Han, "Artificial Intelligence and Agents" (2021) NUS Law Working Paper 2021/019 at [12] [Seng & Tan, "Artificial Intelligence and Agents"]; UKIPO, "Artificial Intelligence and Intellectual Property", *supra* note 8 at [63] and [69].

24 Patents Act 1977 (c 37) (UK) [*PA (UK)*] s 7(3). See also *Thaler v Comptroller General of Patents, Designs and Trade Marks* [2020] EWHC 2412 (Pat) at [26].

25 *Yeda Research and Development Co Ltd v Rhone-Poulenc Rorer International Holdings Inc* [2008] UKHL 43 [*Yeda Research*] at [20]. See also *Dien Ghin Electronic (S) Pte Ltd v Khek Tai Ting* [2011] 3 SLR 227 at [13].

this better accords with (a) AI's current capabilities, and (b) the historical rationales underlying the notion of inventorship.

This section argues that AI entities today cannot, and should not, be considered inventors. It is clear that technology which is simply used as a tool to assist human inventors, such as calculators or data-trackers, does not contribute to the conception of an invention.[26] Nevertheless, as the involvement of AI in the inventive process falls on a spectrum,[27] one still needs to consider AI capabilities at their highest. Here, the "creative machine" developed by one Dr Stephen Thaler, which has ostensibly produced several inventions autonomously, provides a relevant example. Dr Thaler's machine, which he calls the device for the autonomous bootstrapping of unified sentience ("DABUS"), is a combination of two types of artificial neural networks. The first type generates output, while the second type evaluates this output and adjusts the system to encourage salient outcomes (such as those which it deems to produce pleasure).[28] According to Dr Thaler, this architecture – which is "capable of adapting to new scenarios without additional human input" – enabled the production of creative and novel ideas,[29] including two potentially patentable inventions (a food container and a flare).[30] Yet, even for a machine as sophisticated as DABUS, the requisite human element in the creation of these inventions remains undeniable.

For DABUS, Dr Thaler would have had to write the underlying source code and design the system's architecture.[31] Moreover, he had to provide the machine with the appropriate datasets for it to "train".[32] As DABUS was trained by a combination of supervised and unsupervised learning,[33] this would mean that Dr Thaler had to further label at least *some* of these datasets to facilitate the machine's learning. More importantly, DABUS was reliant on Dr Thaler to define what a significant idea or outcome was, and for Dr Thaler to recognise the utility of such an output upon generation. To this end, Dr Thaler admitted that desirable outcomes, such as those which produced pleasure, had to be labelled and defined, which then allowed DABUS to search for and identify concepts which could potentially lead to such consequences.[34] In essence, human input was still required to develop the AI entity for a particular (albeit broad) purpose, to train the AI entity in a particular manner, and to define the objectives and parameters which would guide the AI entity in its operations and eventual output. Lastly, despite the experience garnered by DABUS

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26 Daryl Lim, "AI & IP: Innovation & Creativity in an Age of Accelerated Change" (2018) 52(3) Akron L Rev 813 at 831 [Lim, "AI & IP"].

27 Erica Fraser, "Computers as Inventors – Legal and Policy Implications of Artificial Intelligence on Patent Law" (2016) 13(3) SCRIPTed 305 at 306 [Fraser, "Computers as Inventors"].

28 *Thaler v Commissioner of Patents*, *supra* note 11 at [30]–[33], [39].

29 *Ibid* at [41].

30 *Thaler v Comptroller General of Patents, Trade Marks and Designs* [2021] EWCA Civ 1374 at [3].

31 The fact that Dr Thaler is "the owner of the copyright in the DABUS source code and the computer on which DABUS operates" is potentially – as the Full Federal Court appears to have suggested in *Commissioner of Patents v Thaler*, *supra* note 4 at [121] – a relevant factor in determining if a *human* inventor can be identified for inventions devised by AI systems such as DABUS.

32 Ralph Clifford, "Intellectual Property in the Era of the Creative Computer Program: Will the True Creator Please Stand Up" (1997) 71(6) Tul L Rev 1675 at 1680 [Clifford, "Intellectual Property in the Era of the Creative Computer Program"].

33 *Thaler v Commissioner of Patents*, *supra* note 11 at [37].

34 *Ibid* at [39].

and the contributions of the attendant human inputs, it would have been plausible for the AI entity to generate non-patentable or uncreative ideas, *ie*, duds. This clearly shows that the machine would still have been dependent on Dr Thaler to recognise the creativity and patentability (or otherwise) of the output produced. Thus, although DABUS may have made new links between disparate concepts and generated novel patterns of information,[35] the "creative machine" ostensibly remained reliant on Dr Thaler as regards its development, training, and the assessment of its output's utility.[36]

Given the degree of human intervention,[37] there might understandably be some unease in deeming even such sophisticated "creative machines" as DABUS the "inventors" of the patentable outputs. An analogy may be drawn here with simpler technological models. Consider a human who is attempting to optimise outputs for a non-linear problem. As there could be a potentially large number of variables, optimising these outputs by hand will be near impossible. The human therefore takes advantage of the large amounts of computing power available today to construct a model to reach a desirable solution. In such a scenario, the human might not understand the mathematical intricacies of how the model works, particularly if he or she utilises external software. And even though the technological model may have generated a novel solution to the problem (perhaps even one which the human had never considered or would never have arrived at), one would nevertheless regard the human to have proffered that particular solution, based on his or her input in constructing the broad framework upon which the model – as a *facilitative* tool – operated. In the same way, the "creative machines" of today ought to be viewed as instruments/tools which, by and large, *assist* humans in sifting through voluminous datasets, identifying patterns, drawing linkages and associations, and providing suggestions targeted at defined objectives (such as that which occurs in text and data mining activities).

Secondly, this view of AI entities also accords with the rationales underpinning patent law and inventorship. Patent law has always sought to incentivise the creation, disclosure, and dissemination of technological advances through the provision of (time-limited) economic benefits to patent owners.[38] Such a system thus enables the promotion of innovation and science by rewarding creative and beneficial *human* endeavour.[39] The anthropocentric focus on human creativity may be explained through two reasons. The first is historical. Many modern patent law frameworks draw heavily from relatively dated statutes. For instance, the UK Patents Act 1977 and the Australian Patents Act 1990 trace their lineage back to the English Statute of Monopolies of 1623.[40] Unsurprisingly, the concept of inventorship which existed

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35 *Ibid* at [41].

36 Relevantly, Beach J would himself only consider DABUS to be "semi-autonomous": see *ibid* at [18].

37 The authors recognise that the field of AI is constantly advancing, and that the aforementioned assessment of DABUS's capabilities and the degree of human involvement in the machine's inventive process may be up for technical debate.

38 Yosuke Watanabe, "I, Inventor: Patent Inventorship for Artificial Intelligence Systems" (2021) 57 Idaho L Rev 473 at 492.

39 See *eg*, *First Currency Choice Pte Ltd v Main-Line Corporate Holdings Ltd* [2007] SGCA 50 at [1].

40 *Thaler v Comptroller General of Patents, Trade Marks and Designs*, *supra* note 30 at [33]; *Commissioner of Patents v Thaler*, *supra* note 4 at [112].

and developed at that time would not have entertained the possibility that any entity, other than a human being, could engage in creative activity or possess inventive capacity.

The second, and perhaps more relevant, reason supporting patent law's anthropocentric rationale is a deontological one. Intellectual property regimes have always incorporated a necessary human element. To this end, there are three main justifications for intellectual property protection – the labour theory, the personality theory, and the reward theory (or the utilitarian "incentive" rationale).[41] In sum, the labour theory posits that individuals are entitled to enjoy the fruits of their own productive labour.[42] The personality theory, on the other hand, states that a person's creations are an expression, and thus an extension, of his or her personality.[43] Finally, the reward theory posits that it is only fair to reward a person for producing something which ultimately benefits society.[44] The central idea behind all these justifications taken together is to accord fair protection to the products or output of the human mind,[45] and thus the moral worth of the human creator/inventor.

The evidence of an intrinsic human element in the intellectual property ecosystem may be gleaned from a brief comparison between the concept of authorship in copyright law and that of inventorship in patent law. As is well known, these respective regimes vest the relevant intangible property right in the author, creator, or inventor – the source of human creativity and ingenuity. Authorship requires a causal connection between the work in question and the engagement of the human intellect.[46] Upon the creation of the work, copyright vests automatically in the human author (assuming the other requirements for copyrightability are also satisfied),[47] with the term of protection inextricably tied to the duration of the author's life.[48] Accordingly, the need for authors to be human remains a longstanding tenet in copyright law.[49]

Similarly, upon the grant of a patent, rights are typically vested in the (human) inventor(s).[50] The focus upon the inventor "follows the common practice whereby the creator is accorded the privileged status of first owner of intellectual property

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41 Reto Hilty, Jörg Hoffmann & Stefan Scheuerer, "Intellectual Property Justification for Artificial Intelligence" in Lee Jyh-An, Liu Kung-Chung & Reto Hilty, *Artificial Intelligence & Intellectual Property* (Oxford: Oxford University Press, 2021) at 52–53 [Hilty, Hoffmann & Scheuerer, "Intellectual Property Justification for Artificial Intelligence"].

42 See *eg*, Gordon Hull, "Clearing the Rubbish: Locke, the Waste Proviso, and the Moral Justification of Intellectual Property" (2009) 23 Public Affairs Quarterly 67 at 73–76.

43 See Margaret Jane Radin, "Property and Personhood" (1982) 34(5) Stan L Rev 957 at 971–973; Justin Hughes, "The Philosophy of Intellectual Property" (1988) 77 Geo L J 287 at 330.

44 See Stephen Nathanson, ed, *John Stuart Mill: Principles of Political Economy with Some of Their Applications to Social Philosophy (Abridged)* (Indianapolis: Hackett Publishing, 2004) at 271.

45 David Vaver, "Intellectual Property: The State of the Art" (2000) 116 LQR 621 at 621. See also Daniel Gervais, "The Machine as Author" (2020) 105(5) Iowa L Rev 2053 at 2079.

46 David Tan, "Designing a Future-Ready Copyright Regime in Singapore: Quick Wins and Missed Opportunities" (2021) 70 GRUR International 1131 at 1132.

47 See *eg*, Copyright, Designs and Patents Act 1988 (c 48) (UK) [*CDPA*] s 3.

48 See *ibid* s 12(2).

49 See Sam Ricketson, "People or Machines: The Berne Convention and the Changing Concept of Authorship" (1991–1992) 16 The Columbia Journal of Law & the Arts 1 at 11, 21–22 and 34–35.

50 See *PA (UK)*, *supra* note 24 s 7(2)(*a*); Fraser, "Computers as Inventors", *supra* note 27 at 331.

rights".[51] As such, the capacity to devise patentable inventions has always been regarded as the domain of humans, with patentable concepts recognised as "mental creation(s) by a human being".[52] This is also supported by the dominant view in patent and copyright jurisprudence across jurisdictions that only humans may qualify as inventors and authors. In patents for instance, it has been held that under the European Patent Convention ("EPC"),[53] the UK Patents Act 1977,[54] the US Patent Act,[55] and the Australian Patents Act 1990,[56] inventors can only refer to natural persons (or, in the European context, persons "with legal capacity").

Notwithstanding that these anthropocentric justifications are still applicable to the *current* state of AI developments, the thoughtful reader may, at this juncture, ponder whether they will *continue* to remain relevant going forward, given the unabating advancements in AI capabilities. Specifically, when AI entities become *fully* autonomous such that AI-generated inventions become a reality, why should patent law in particular be bound by historical considerations and anachronistic anthropocentrism? The authors agree entirely. The point that this section makes, however, is that the current state of AI technology can still be accommodated within the present framework of anthropocentric patent laws. From AI entities which function as focused research-based tools to the (much rarer) "creative" AI systems with broader (higher level) capabilities, the degree of human input or decision-making required in producing patentable inventions adequately justifies the *denial* of inventorship status to these machines. Instead, the current wisdom on the subject is in deference to the recognition of full inventorship status for such "AI-assisted" inventions in favour of the respective *humans* involved – either as sole or joint inventors.

This is further evidenced by the UK government's recent decision to make no changes to UK's patent legislation, in particular to the rules on inventorship, for the time being.[57] While such wait-and-see approaches remain defensible in the

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[51] Lionel Bently, Brad Sherman, Dev Gangjee & Phillip Johnson, *Intellectual Property Law*, 5th ed (Oxford: Oxford University Press, 2018) at 623.

[52] Cyril Soans, "Some Absurd Presumptions in Patent Cases" (1966) 10 Patent, Trademark and Copyright Journal of Research and Education 433 at 438. See also *Burroughs Wellcome Co v Barr Laboratories, Inc* 40 F.3d 1223 (Fed Cit 1994) at 1227–1228.

[53] Decision of the EPO's Legal Board of Appeal, Case No. J 0008/20 <https://www.epo.org/law-practice/case-law-appeals/recent/j200008eu1.html> (21 December 2021) at [4.3.1], [4.3.2], [4.7.3] [Decision of the EPO's Legal Board of Appeal]; Decision of the Receiving Section of the EPO <https://www.epo.org/news-events/news/2020/20200128.html> (27 January 2020) at [23]–[24] [Decision of the Receiving Section of the EPO]; see also "EPO refuses DABUS patent applications designating a machine inventor" <https://www.epo.org/news-issues/news/2019/20191220.html> (20 December 2019).

[54] UKIPO, Decision BL O/741/19 on 4 December 2019 <https://www.ipo.gov.uk/p-challenge-decision-results/o74119.pdf> at [18]–[19]; *Thaler v Comptroller General of Patents, Trade Marks and Designs*, *supra* note 30 at [49]–[55], [102], [116]–[123].

[55] *Thaler v Vidal*, 43 F.4th 1207 at 5–9 (Fed Cit, 2022); *Thaler v Hirshfeld* 558 F Supp 3d 238 at 6 (4th Cir, 2021). See also Clifford, "Intellectual Property in the Era of the Creative Computer Program", *supra* note 32 at 1696–1697.

[56] *Commissioner of Patents v Thaler*, *supra* note 4 at [113].

[57] UKIPO, "Consultation Outcome: Artificial Intelligence and Intellectual Property: copyright and patents: Government response to consultation" <https://www.gov.uk/government/consultations/artificial-intelligence-and-ip-copyright-and-patents/outcome/artificial-intelligence-and-intellectual-property-copyright-and-patents-government-response-to-consultation#patents> (28 June 2022) at [79] [UKIPO, "Consultation Outcome", 28 June 2022].

short-term given the absence of a clear consensus on AI's current capabilities,[58] the real prospect of fully (and undisputedly) autonomous AI inventors materialising necessitates an *expedited* consideration of appropriate legal responses so as to ensure that patent regimes globally are not inadvertently caught on the back foot.[59] This issue forms the subject of discussion in the following section.

III. The way forward amid full AI autonomy

Although AI capabilities at present, according to the preponderance of opinion, may not necessarily pose significant problems for existing patent law frameworks,[60] the advent of "creative machines" such as DABUS as well as the speed at which technology advances in this field portend that fully autonomous AI entities may soon arrive on the scene. At that stage, the AI entity will likely replace humans as the primary actor in driving scientific discovery and creative expression.[61] This phenomenon has widely been termed the attainment of "artificial general intelligence", which encompasses the abilities of AI entities to independently reason, plan, and learn in order to achieve particular goals.[62] It is submitted that current patent laws and frameworks will no longer be able to accommodate such developments, which can only reinforce the importance of pre-empting these challenges before (rather than when) they occur.

As briefly canvassed in the previous section, patent legislation across the different jurisdictions is heavily influenced by historical anthropocentric considerations. These laws have typically been interpreted as confirming the position that inventorship is to be reserved *exclusively* for natural persons.[63] For example, the Receiving Section of the European Patent Office ("EPO") decided in January 2020 that the legal framework of the EPC only allows for natural persons to be inventors. To support this position, the EPO considered the legislative history of the EPC[64] and the other provisions within the EPC, which did not provide for non-persons in any capacity.[65] It also noted that the EPC vests various rights upon the inventor, which

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58 See *eg*, *ibid* at [2] and [67]. See also Oscar Davis, "A Google software engineer believes an AI has become sentient. If he's right, how would we know?" <https://theconversation.com/a-google-software-engineer-believes-an-ai-has-become-sentient-if-hes-right-how-would-we-know-185024> (14 June 2022) [Davis, "A Google software engineer"], where the author suggests that "our understanding of sentience and consciousness [and arguably, intelligence] in AI systems might be limited by our own particular brand of intelligence".

59 In this regard, it is heartening that the UKIPO has resolved, *inter alia*, to "advance AI inventorship harmonization discussions in international fora": see UKIPO, "Consultation Outcome", 28 June 2022, *supra* note 57 at [80].

60 Ichiro Nakayama, "Patentability and PHOSITA in the AI Era – A Japanese Perspective" in Lee Jyh-An, Liu Kung-Chung & Reto Hilty, *Artificial Intelligence & Intellectual Property* (Oxford: Oxford University Press, 2021) at 102; Noam Shemtov, *A study on inventorship in inventions involving AI activity*, commissioned by the European Patent Office (2019) at 22 [Shemtov, *A study on inventorship*].

61 Lim, "AI & IP", *supra* note 26 at 833.

62 David Weinbaum & Viktoras Veitas, "Open Ended Intelligence: The Individuation of Intelligent Agents" (2017) 29(2) Journal of Experimental & Theoretical Artificial Intelligence 371 at 372.

63 Note, however, jurisdictions which do not require inventors to be named, such as Israel.

64 Decision of the Receiving Section of the EPO, *supra* note 53 at [24].

65 *Ibid* at [23].

AI entities are unable to possess as they are not recognised as legal persons. These conclusions were subsequently affirmed by the EPO's Legal Board of Appeal.[66] Similarly, the UK Court of Appeal held that the UK Patents Act 1977 was drafted on the understanding that an inventor was meant to be a natural person.[67] The court arrived at this conclusion after examining the natural meaning of the relevant terms,[68] the other provisions within the statute,[69] and the moral rights accompanying inventorship.[70] In the US, the Patent and Trademark Office, the US District Court for the Eastern District of Virginia, as well as the US Court of Appeals for the Federal Circuit have held the view that an inventor must refer to a natural person.[71] The District Court arrived at its decision after considering the ordinary meaning of the word "individual" (as referring to a natural person) and existing US case law.[72] This decision was affirmed on appeal by the Federal Circuit, which held that the plain and unambiguous meaning of the text in the Patent Act limited the term "inventor" to natural persons.[73] This position has also been adopted by the patent offices in Japan, China, South Korea, and (most recently) New Zealand.[74]

Reserving inventorship for natural persons will effectively prevent patents from being granted for inventions devised by completely autonomous AI entities. This may result in either (a) the non-disclosure of such inventions by the owners of these AI entities, or (b) the inaccurate (but intentional) designation of humans as the inventors of such inventions. In the former scenario, these inventions will likely be held as trade secrets.[75] The lack of patent protection for these inventions might impede innovation by not only deterring the commercialisation of such inventions for fear of reverse-engineering efforts by competitors,[76] but also by preventing contributions to the existing repository of scientific/technical knowledge upon which new discoveries and breakthroughs might follow. In the latter scenario, the owners of the AI entities may attempt to designate either themselves or other humans as

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66 Decision of the EPO's Legal Board of Appeal*, supra* note 53 at [4.3.1]–[4.3.9], [4.7.3].

67 See *Thaler v Comptroller General of Patents, Trade Marks and Designs*, *supra* note 30 at [51]–[53], [97], [102]–[103], [116]–[123]. More recently, the Full Court of the Federal Court of Australia also arrived at the same conclusion vis-à-vis the Patents Act 1990 (Aust) – see *Commissioner of Patents v Thaler*, *supra* note 4 at [113].

68 *Thaler v Comptroller General of Patents, Trade Marks and Designs*, *ibid* at [116].

69 *Ibid* at [51]–[52], [102], [117]–[120].

70 *Ibid* at [121].

71 *Thaler v Vidal*, *supra* note 55 at 5–9; *Thaler v Hirshfeld*, *supra* note 55 at 4–8.

72 *University of Utah v Max-Planck-Gesellschaft Zur Forderung Der Wissenschaften E.V*. 734 F.3d 1315 at 1323 (Fed Cit, 2013). See also *Beech Aircraft Corp. v Edo Corp.* 990 F.2d 1237 at 1248 (Fed Cit, 1993).

73 *Thaler v Vidal*, *supra* note 55 at 9: "This is a case in which the question of statutory interpretation begins and ends with the plain meaning of the text". It was further observed by the Federal Circuit that its decision in *Thaler* was also supported by its own precedent.

74 Five IP Offices, "Report from the IP5 expert roundtable on artificial intelligence" <https://www.fiveipoffices.org/sites/default/files/attachments/5e2c753c-54ff-4c38-861c-9c7b896b2d44/IP5+roundtable+on+AI_report_22052019.pdf> (31 October 2018) at 2; Stephen Thaler [2022] NZIPOPAT 2 <http://www.nzlii.org/nz/cases/NZIPOPAT/2022/2.html> at 2, 5, 9, 10.

75 See Abbott, "I Think, Therefore I Invent", *supra* note 5 at 1104–1105; *Thaler v Commissioner of Patents*, *supra* note 11 at [130].

76 See Abbott, "I Think, Therefore I Invent", *ibid* at 1105; Edmund Kitch, "The Nature and Function of the Patent System" (1977) 20 The Journal of Law & Economics 265 at 276–77 [Kitch, "The Nature and Function of the Patent System"].

the inventors of these AI-generated inventions to acquire patent protection under current laws. While this misleading (or, as some might argue, fraudulent) endeavour[77] risks the rejection of the patent application and the invalidation of the patent in jurisdictions such as the US,[78] these inaccuracies, in practice, are likely to escape scrutiny because (a) these inventions are typically produced in-house and AI entities cannot conceivably challenge the accuracy of such patent applications, and (b) patent applications in general are not examined substantively on questions of inventorship. However, with the advancing capabilities of patent examination offices globally as well as a growing culture of partnerships across firms and industries,[79] the increased likelihood that such inaccuracies will eventually be uncovered renders this latter approach undesirable.

Accordingly, it is submitted that this incongruence between AI-generated inventions and current patent law frameworks can only be resolved by Parliament through amendments to existing legislation. This is for two main reasons. First, "modern patent law is almost entirely a creature of statute".[80] Legislation will therefore serve as an exhaustive code to promulgate, *inter alia*, which persons qualify as inventors.[81] Moreover, given that only natural persons may qualify as inventors and own patents pursuant to most (if not all) patent statutes at present, the accommodation and judicial recognition of AI inventors within the existing provisions will appear forced and hence artificial.[82] Indeed, as the Full Court of the Federal Court of Australia has aptly cautioned, "the Court must be cautious about approaching the task of statutory construction by reference to what it might regard as desirable policy, imputing that policy to the legislation, and then characterising that as the purpose of the legislation".[83] Secondly, the variegated policy considerations surrounding the grant of patent protection for AI-generated inventions will require careful evaluation and thoughtful debate. To this end, Parliament (rather than the judiciary) remains the best forum to address the concomitant economic, legal, and social implications.[84]

This, then, begs the question of *how* existing patent legislation should be amended. This article makes two recommendations: (a) the recognition of fully autonomous AI entities as "inventors", and (b) the grant of patent ownership to the owners of these entities as a default rule.

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77 Lim, "AI & IP", *supra* note 26 at 861.

78 See *In re Verhoef* 888 F.3d 1362 at 1367–1368 (Fed Cit, 2018).

79 See *eg*, open-source projects and platforms such as "TensorFlow": Hilty, Hoffmann & Scheuerer, "Intellectual Property Justification for Artificial Intelligence", *supra* note 41 at 63–64.

80 See *Thaler v Comptroller General of Patents, Trade Marks and Designs*, *supra* note 30 at [100], [136].

81 *Yeda Research*, *supra* note 25 at [18]–[20].

82 As observed by Laing LJ in *Thaler v Comptroller General of Patents, Trade Marks and Designs*, *supra* note 30 at [103] ("[i]f patents are to be granted in respect of inventions by machines, the 1977 Act will have to be amended").

83 *Commissioner of Patents v Thaler*, *supra* note 4 at [120].

84 See *eg*, Decision of the EPO's Legal Board of Appeal, *supra* note 53 at [4.6.6]: "… it is the task of the lawmakers to amend the EPC and to assess whether a real problem exists. Different solutions may be conceivable to the issue raised by the appellant. It is not for the Board to select one of the possible approaches".

A. *Extending Inventorship to Encompass Fully Autonomous AI Entities*

This section argues that fully autonomous AI entities should be recognised as "inventors" because (a) this accords with the reality of the AI's technical and inventive independence, and (b) this perspective best safeguards the moral rights which accompany inventorship. On the other hand, the authors submit that views inspired by copyright law – such as to designate as inventors the humans who undertook "the arrangements necessary for the devising of the invention"[85] – should *not* be adopted.

On the first point, the AI entities' ability to generate patentable inventions autonomously accords with the essence of inventorship. As previously mentioned, an inventor is defined statutorily as "the actual deviser of the invention" in a number of common law jurisdictions, such as the UK[86] and Singapore.[87] In the US, "inventor" is defined as the individual(s) "who invented or discovered the subject matter of the invention".[88] Conversely, the relevant legislation in other common law jurisdictions such as Australia[89] and Hong Kong[90] do not explicitly define "inventor". In any case, the judicial thinking across these jurisdictions suggests that the crux of inventorship concerns the quality of the *contributions* made towards the devising of the invention. This principle has been expressed in myriad ways – from contributions toward an invention's "conception"[91] (which refers to "the formation in the mind … of a definite and permanent idea of the complete and operative invention as it is thereafter to be applied in practice")[92] or the "inventive concept"[93] (which is commonly described as "the heart" of the invention),[94] to a contribution without which the "invention would not have come about".[95]

Given this understanding of inventorship, it is difficult to see how in this scenario, any other person or entity – other than the fully autonomous AI entity itself – can lay claim to being named the "inventor".[96] Although AI entities may not "think" in the same ways that humans do, it is submitted that their devising of patentable inventions autonomously should nonetheless satisfy the requisite contributions toward an

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85 See UKIPO, "Artificial Intelligence and Intellectual Property", 29 October 2021, *supra* note 8; *CDPA*, *supra* note 47 s 9(3).

86 *PA (UK)*, *supra* note 24 s 7(3). See also *Yeda Research and Development Co Ltd v Rhone-Poulenc Rorer International Holdings Inc*, *supra* note 25 at [20].

87 Patents Act 1994 (2020 Rev Ed Sing) s 2.

88 35 USC (US) § 100(f) (2019).

89 See *Thaler v Commissioner of Patents*, *supra* note 11 at [59]; Patents Act 1990 (Aust).

90 Patents Ordinance (Cap 514) (HK).

91 US Patent & Trademark Office, "Manual of Patent Examining Procedure" (Rev 10.2019, June 2020) at § 2109 and § 2138.04.

92 *Townsend v Smith* 36 F. 2d 292 at 295 (CCPA, 1929); *Hybritech Inc v Monoclonal Antibodies Inc* 802 F. 2d 1367 at 1376 (Fed Cit, 1986).

93 *Dien Ghin Electronic (S) Pte Ltd v Khek Tai Ting*, *supra* note 25 at [13].

94 *Markem Corp v Zipher Ltd* [2005] EWCA Civ 267 at [102].

95 *JMVB Enterprises Pty Ltd v Camoflag Pty Ltd* (2005) 67 IPR 68 at [132] [FCA, Cth].

96 See *eg*, *Thaler v Comptroller General of Patents, Trade Marks and Designs*, *supra* note 30 at [79] ("Just because all inventors are people, this case demonstrates that it does not follow that all inventions have a person who invented them.") and [110] ("It may be that the facts of this case show that a machine can devise an invention …").

invention's "conception".[97] Unlike AI entities at present which still rely on humans (or human input) for various aspects of their operations, fully autonomous AI entities will presumably be able to invent without *any* intervention whatsoever from human actors (save perhaps in the writing of the initial code). Assuming the initial code does not provide for specific directions on the operation and goals/objectives of the AI system but merely sets up a rough framework upon which the AI entity learns and operates in ways unknown and unpredictable to humans, the latter will arguably remain completely clueless as to the resulting inventive concept(s) which the AI entity may formulate. Specifically, until explicitly demonstrated by the AI, the human will not know what types of problems the inventions produced by the AI will solve, which fields these inventions will target, or even the potential effects or utility of these inventions. In such cases, recognising the AI entity as the "actual deviser" of the invention will give effect to the *reality* that the natural person has played no qualitatively significant role in the inventive process, much less provided a vital contribution to the formulation of the inventive concept. This position will also circumvent all uncertainty regarding who, if not the AI entity, ought to be recognised as the appropriate "inventor" for patent law purposes.[98]

On the second point, recognising AI entities as inventors will best safeguard the sanctity of the moral rights which accompany inventorship, in particular the "paternity" right of attribution.[99] For natural persons, being acknowledged as the inventor not only provides added significance in the realm of moral rights, but also economic value as a signal of productivity.[100] The recognition of the creativity and ingenuity of a particular individual or group of individuals has significant meaning for scientists and engineers who gain professional credibility and monetary benefits through their status as "inventors".[101] If fully autonomous AI entities are not recognised as inventors, this may, in practice, lead to the inaccurate designation of humans as the inventors of AI-generated inventions. It is submitted that these incorrect – or, as alluded to above, misleading and/or fraudulent – designations of humans as inventors will invariably compromise the deontological significance of the moral right of attribution. For example, the inaccurate designation of humans as inventors will likely dilute the moral and economic benefits which accompany the right of attribution. This is because the status of "inventor" can no longer meaningfully signify *human* creativity and ingenuity if humans, completely uninvolved in the inventive process, are allowed to take credit for an invention autonomously devised by an AI entity. The recognition of AI entities as inventors under these circumstances will therefore prevent individuals from being undeservedly credited, enhance transparency in the

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97 This has been termed the "functionalist" approach which focuses on the output produced: see Shemtov, *A study on inventorship*, *supra* note 60 at 28.

98 Nick Li & Koay Tzeyi, "Artificial Intelligence and Inventorship: An Australian Perspective" (2020) 15(5) JIPLP 399 at 402.

99 See *PA (UK)*, *supra* note 24 s 13; *Thaler v Comptroller General of Patents, Trade Marks and Designs*, *supra* note 30 at [121].

100 Ryan Abbott, *The Reasonable Robot: Artificial Intelligence and the Law* (Cambridge University Press, 2020) at 79 [Abbott, *The Reasonable Robot*].

101 Fraser, "Computers as Inventors", *supra* note 27 at 331.

patent system, and preserve the (especially moral) benefits which accompany the "paternity" right of attribution.[102]

True it is that moral rights, being personal rights, may only be held by natural persons,[103] which AI machines are not. Nevertheless, at least some of the deontological justifications that underpin the existence of moral rights arguably apply with equal force to AI entities. Such entities should also be entitled to the fruits of their "labour" and be "rewarded" for inventions which ultimately benefit society. Even though one might argue that there has been no real "labour" invested in AI-generated inventions (as AI machines simply run algorithms and processes) and it is true that the nature of an AI's "labour" is distinctly different from the traditional sweat-filled (human) effort one might romantically envision, it is unclear why, *ipso facto*, this necessarily means that the former is not at all worthy of moral recognition.[104] One should not, in any event, lose sight of the fact that AI entities (such as artificial neural networks) do operate/function in ways highly similar to that of the human brain.[105] On this line of reasoning that pays due regard to what may loosely be called "mental" (or "metaphysical") "labour", autonomous AI entities well deserve recognition for their work in generating socially useful (and hence patent-eligible) inventions. The thrust of this argument further accords with the broader remit and focus of patent law on protecting patent-eligible *output* (namely, inventions which are novel, inventive and socially useful), and *not* specifically the "human" mental processes involved in conceptualising such output.[106] It therefore follows that in the absence of any meaningful distinction between AI-generated and human-generated inventive output, suggestions for a *sui generis* framework to protect AI-generated inventions[107] might not only be conceptually unnecessary (or even untenable),[108] but also unfair.[109] The better option, it is submitted, is for investments in AI entities

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[102] Ryan Abbott, "Artificial intelligence, big data and intellectual property: protecting computer generated works in the United Kingdom" in Tanya Aplin, *Research Handbook on Intellectual Property and Digital Technologies* (Elgar Publishing, 2020) at 326.

[103] *Thaler v Comptroller General of Patents, Trade Marks and Designs*, *supra* note 30 at [121].

[104] See Shemtov, *A study on inventorship*, *supra* note 60 at 21 ("it is not necessary for the invention to result from a particular type of inventive effort of the inventor").

[105] The authors surmise that it might well be due to innate human or cognitive biases that has led one writer, as alluded to above, to suggest that "our understanding of sentience and consciousness [and arguably, intelligence] in AI systems might be *limited* by our *own* particular brand of intelligence": see Davis, "A Google software engineer", *supra* note 58 (emphasis added).

[106] See Peter Georg Picht, Valerie Brunner & Rena Schmid, "Artificial Intelligence and Intellectual Property Law: From Diagnosis to Action" (2022) Max Planck Institute for Innovation and Competition Research Paper No. 22-08 at 18 [Picht, Brunner & Schmid, "Artificial Intelligence and Intellectual Property Law"]; Abbott, "I Think, Therefore I Invent", *supra* note 5 at 1108*ff* (especially at 1110–1111); Shemtov, *A study on inventorship*, *supra* note 60 at 28.

[107] See UKIPO, "Artificial Intelligence and Intellectual Property", 29 October 2021, *supra* note 8. Under "Option 3", a proposed *sui generis* (patent-like) regime would operate alongside the current patent system and offer rather more limited protection to AI-generated inventions. The authors are mindful that the preponderance of academic views caution against such a development, citing implementation risks and potential legal uncertainty: see *eg*, Tanya Aplin, Burkhard Schafer & Phoebe Li, "Response to UK IPO Open Consultation on AI and IP: Copyright and Patents" (7 January 2022) at [11.4]; Picht, Brunner & Schmid, "Artificial Intelligence and Intellectual Property Law", *supra* note 106 at 26.

[108] See *eg*, UKIPO, "Consultation Outcome", 28 June 2022, *supra* note 57 at [77].

[109] The purported unfairness is premised on the fact that patentable inventions devised by fully autonomous AI entities, which arguably perform the same role as human-generated inventions in "further[ing] the

(and their resulting inventions) to be protected by way of an extension of – and *not* from outside – the patents regime.

Detractors also argue that rewards and incentives arising from the reward theory are inherently tied to *human* inventorship.[110] The argument goes that there is no need to reward AI entities since they do not at all require incentives to innovate. In other words, AI machines will continue to invent even in the absence of attribution/reward. The present authors fully agree with these views, but will instead argue that the reward theory is, in the specific context of AI-generated inventions, perhaps more geared towards incentivising *patent owners*, rather than the machine inventors themselves. By granting patent ownership for such inventions, the reward of temporally limited monopolies serves to create incentives for patent owners to maximise social welfare through continued investment (and R&D) in AI technology.[111] On the other hand, it is submitted that the reward of attribution for AI-generated inventions is based *primarily* on the principle of fairness and the recognition of inventive merit, rather than the provision of economic incentives and benefits to inventors. When viewed in this light, paternity rights are accorded on the basis that the social utility gained from patentable AI-generated inventions justifies the *moral* recognition of the machine inventors concerned.[112]

Accordingly, for the above two reasons, the authors submit that it is for Parliament to amend existing patent legislation to extend the scope of inventorship to encompass fully autonomous AI entities, if and when they become a reality. It should, however, be noted at this juncture that the UK Intellectual Property Office ("UKIPO") has also proposed a possible middle ground by expanding the term "inventor" to include the "humans responsible for an AI system which devises inventions" (classed as "Option 1").[113] Option 1 takes its inspiration from copyright law[114] and designates the "human who made the arrangements necessary for the AI to devise the invention" as the inventor. According to the UKIPO, this option will preserve the meaning of the term "inventor" as it is currently understood and allow patent ownership to flow directly to the human(s) involved. A similar idea has also been canvassed by Marcus Smith J in the UK High Court who opined that it was not unarguable that the "owner/controller of an artificially intelligent machine that 'invents' something" could be regarded as the "actual deviser of the invention".[115]

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technological prosperity of society", are not accorded protection under the very intellectual property regime designed to incentivise and reward such outcomes: see Matthew Fisher, *Fundamentals of Patent Law: Interpretation and Scope of Protection* (London: Hart Publishing, 2007) at 93 (who discusses the purpose of the patent system).

110 See *eg*, Eva Stankova, "Human Inventorship in European Patent Law" (2021) 80(2) CLJ 338 at 362–363.

111 See Richard Spinello & Maria Bottis, *A Defense of Intellectual Property Rights* (Cheltenham: Elgar Publishing, 2009) at 167.

112 See *ibid* at 160.

113 See UKIPO, "Artificial Intelligence and Intellectual Property", 29 October 2021, *supra* note 8. Under "Option 1", people involved in the following activities could potentially be considered human inventors: programming the AI, configuring the AI, operating the AI, selecting input data such as training data for the AI or recognising applications of the output of the AI.

114 See *CDPA*, *supra* note 47 s 9(3).

115 *Thaler v Comptroller General of Patents, Designs and Trade Marks*, *supra* note 24 at [52(2)] (and see also [49(3)(d)]). *Cf* also *Commissioner of Patents v Thaler*, *supra* note 4 at [121]; Decision of the EPO's Legal Board of Appeal, *supra* note 53 at [4.6.6].

While the UKIPO's "Option 1" proposal overcomes the tricky issue regarding patent ownership for AI-generated inventions, it is, with respect, submitted that its adoption will necessarily compromise the meaning and full significance of the term "inventor" – because it artificially equates a *lower* "neighbouring rights" standard in copyright law regarding the making of arrangements necessary for the creation of a computer-generated work with the *much higher* standard in patent law regarding the actual devising of an invention. Moreover, it may be argued that the rationale in copyright law for adopting a lower "neighbouring rights" standard for computer-generated works is because of the corresponding grant of a fixed (and far more limited) period of copyright protection for such works – that is, 50 years as opposed to the typical duration of life of the author plus 70 years.[116] The justification for transposing this lower standard for computer-generated copyright works to delineate the identity of the "inventor" where AI-generated inventions are concerned appears less compelling as the term of patent protection is ordinarily fixed by statute at 20 years, regardless of whether the inventor is deemed a natural person or an AI entity. For all these reasons, the authors' preference is for the explicit and more realistic recognition of fully autonomous AI entities as the putative "inventors" of the resulting inventions they generate – an approach which, parenthetically, has been classed by the UKIPO in its public consultation paper as "Option 2".[117]

As a final observation on this recommendation, the main obstacle which Parliaments may face in enacting this change is to consider how the conditions/standards for patentability might be affected going forward. In particular, legislators may have legitimate concerns about the identity of the "person of ordinary skill in the art", and whether, and if so how, the standards for the novelty and non-obviousness requirements will change. The notional person having ordinary skill in the art is assumed to have the capability to canvass the relevant literature (the state of the art) but is unimaginative with no inventive capacity.[118] While a comprehensive assessment of these questions lies beyond the scope of this article,[119] Parliaments will need to address two fundamental issues: (a) whether the "person of ordinary skill in the art" should conform to a uniform standard across AI-generated and human-generated inventions, and (b) if yes, whether the "person of ordinary skill in the art" should refer to the hypothetical natural person or the hypothetical AI entity (or a combination of the two) and what the relevant standard ought to be.[120] The manner in which Parliaments choose to answer all these questions will determine the viability of recognising AI machines/systems as "inventors" and the impact of fully autonomous AI inventors on the standards for patentability. To this end, two main options present themselves.

The first is to raise the bar for patentability by having patent examiners take into account AI capabilities in the assessment criteria. In other words, the person skilled

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[116] See, in particular, *CDPA*, *supra* note 47 *s* 12(7).

[117] See UKIPO, "Artificial Intelligence and Intellectual Property", 29 October 2021, *supra* note 8.

[118] *Technograph Printed Circuits Ltd v Mills & Rockley (Electronics) Ltd* [1972] RPC 346 at 355.

[119] For further reading, see Noam Shemtov & Garry Gabison, "The Inventive Step Requirement and the Rise of the AI Machines" in Ryan Abbott, ed, *Research Handbook on Intellectual Property and Artificial Intelligence* (Massachusetts: Edward Elgar, 2022).

[120] See Daniele Fabris, "From the PHOSITA to the MOSITA: Will 'Secondary Considerations' Save Pharmaceutical Patents from Artificial Intelligence?" (2020) 51 IIC 685 at 690–693.

in the art – for the purposes of assessing, *inter alia*, the inventive step requirement – would be taken to possess the capabilities of a person *who has access to and utilises* AI technology which is available to the public.[121] The advantage of this option is that it prevents unwarranted monopolies being granted where AI technology has been employed in the inventive process, which may in turn lead to "patent thickets" developing in certain fields.[122] However, the adoption of this uniform standard must mean that this "higher" threshold will also be applied when examining human-generated inventions. While some scholars argue that this change is desirable as applying a uniform lower standard would, in essence, amount to rewarding ignorance of the state of the art,[123] one must be careful not to unduly prejudice inventors who operate without the use of AI technology. Yet, as AI technology continues to advance and the adoption of AI becomes more widespread, these unassisted human inventors will increasingly find themselves between a rock and a hard place – if standards are raised, they may face greater difficulties in meeting them and in competing with AI entities; if standards are not, then the patent system may see a proliferation of applications (and a corresponding influx of patentable inventions) in fields which they could otherwise have penetrated. If, however, one accepts that AI technology is here to stay,[124] then adopting the higher standard may well incentivise all, if not most, human inventors to incorporate such sophisticated technologies in their R&D work. Nevertheless, these competing policy considerations ought to be fully ventilated and debated in Parliament, including the possible reconsideration of received wisdom that a person skilled in the art, particularly in the age of AI, merely refers to an "averagely-skilled" workman or technician who possesses "common general knowledge" but who does not have inventive capacity.[125]

Alternatively, Parliaments may consider adopting different standards for AI-generated inventions and human-generated inventions. This will essentially entail creating a sub-category of rules for AI-generated inventions.[126] The benefit of this option comes from comparing apples with apples – AI-generated inventions will be pegged to a "higher" AI standard, with human-generated inventions pegged to the conventional standard of the "person of ordinary skill in the art". Alas, this approach faces its own problems. Parliaments, for instance, will need to consider how much "higher" the AI standard should be and how that should be assessed – such as whether it will be based on an average degree of computing power or architectural complexity. This might, in turn, require upgrades in the capabilities and expertise of patent examination offices in these jurisdictions. Of greater concern, however, to jurisdictions that adopt this option is to determine how the owners of AI entities may be deterred from inaccurately (indeed unethically) declaring themselves and/or other humans as the "inventor(s)" of AI-generated inventions, so as to take advantage of the lower standard.

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[121] See *Thaler v Commissioner of Patents*, *supra* note 11 at [145]; Anne Lauber-Ronsberg & Sven Hetmank, "The concept of authorship and inventorship under pressure: Does artificial intelligence shift paradigms?" (2019) 14(7) JIPLP 570 at 578–579.

[122] Fraser, "Computers as Inventors", *supra* note 27 at 322–323.

[123] *Ibid* at 321.

[124] See *eg*, Schuster, "Artificial Intelligence and Patent Ownership", *supra* note 7 at 1947.

[125] See also *Commissioner of Patents v Thaler*, *supra* note 4 at [119].

[126] Lim, "AI & IP", *supra* note 26 at 863.

It therefore appears, on balance, that a *uniform* "higher" standard for patentability is likely the best option.[127] This will not only encourage the adoption of AI technology in the inventive process but also prevent the inaccurate designation of humans as inventors, which the recommendation in this section aims to avoid. There is also no need to address the tricky situation of deciding which of the two standards to apply where humans and AI entities collaborate as "joint inventors" in devising the invention in question. Nevertheless, further dialogue with the technology industry is preferable so as to establish the appropriate standard (through a measurement of computing power for instance) and determine how this heightened standard can be effected through legislation.

In any case, the authors remain of the view that the various difficulties and challenges raised in this section are not entirely insurmountable and, more crucially, should not prevent the *realistic recognition* of AI entities as inventors if and when fully autonomous machine inventors become a reality.[128] Indeed, there is much wisdom in Beach J's perceptive observation thus: "We are both created and create. Why cannot our own creations also create?"[129]

B. *Granting Patent Ownership to the Owner of the Fully Autonomous AI Entity by Default*

While the authors have recommended that fully autonomous AI entities be recognised as inventors, it is trite law that these machines cannot be the owners of the relevant patents because they are not legal persons. These entities cannot possess or enforce any rights – such as executing assignments/licenses or bringing suits for patent infringement – nor hold any property.[130] Humans (or, more generally, legal persons) must thus remain the owners of any resulting patent rights.[131] To this end, this section argues that patent ownership of an AI-generated invention should be granted to the owner of the AI entity by default, for these reasons: (a) this recommendation best furthers the underlying objectives of patent law to maximise social welfare, encourage innovation, and incentivise investment in (and more widespread use of) AI technology; and (b) various doctrinal arguments may be made to justify why the owners of AI entities should also own the accompanying rights to AI-generated inventions.

First, as previously mentioned, patent law seeks to incentivise the creation, disclosure, and dissemination of technological advances. In doing so, the base of scientific and technical knowledge will continue to grow, thereby creating a positive

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[127] See Ryan Abbott, "Everything is Obvious" (2018) 66 UCLA Law Review 2 at 34 and 37; Susan Tull & Paula Miller, "Patenting Artificial Intelligence: Issues of Obviousness, Inventorship, and Patent Eligibility" (2018) 1 The Journal of Robotics, Artificial Intelligence and Law 313 at 320.

[128] See also *Thaler v Commissioner of Patents*, *supra* note 11 at [126], [145].

[129] *Ibid* at [15].

[130] See *Thaler v Comptroller General of Patents, Designs and Trade Marks*, *supra* note 24 at [49(1)].

[131] See *Thaler v Commissioner of Patents*, *supra* note 11 at [133]. Even if legal personhood were to be granted to AI entities (an issue that is beyond the scope of this article), the further question of which humans should be entitled to make decisions on behalf of these entities may still need to be answered.

feedback system where further advances can be achieved[132] and resulting in greater social welfare and utility.[133] Given these goals, it is submitted that such incentives ought to be directed at the *owners* of the AI entities. These owners, who are typically wealthy corporations or even individuals, possess the capital to fund continued R&D in the field of AI. These funds also go towards paying for the creation, testing, and maintenance of AI entities by providing the technological infrastructure and the remuneration of relevant expertise. Moreover, as owners will presumably possess sole control over access to both the AI entities and their output, it follows that incentives aimed at disclosure should be targeted at them. Therefore, granting patent ownership of AI-generated inventions to the owners of AI machines by default will likely encourage innovation and engender social benefits to a greater extent as compared to according such rights to, say, the user or developer of the AI entity concerned.[134] This proposal also provides for greater *certainty* given that these owners are typically easier to identify without dispute than developers and users, since many other individuals may well have played various roles in the creation, development, and operation of AI entities. This is a point to which we will return below.

Secondly, several doctrinal arguments may be canvassed to justify why owners of AI entities should, by default, own the patent rights to inventions created by machines. For example, this would be consistent with the way personal property is typically treated: if a person owns a machine which produces some form of property, then that person ought to also own the property produced.[135] This idea can be traced to the principle of *accession*, which refers to the granting of title to a resource based on its relationship to something already owned.[136] The doctrine of accession originates from Roman civil law,[137] and applies to situations such as "the growth of vegetables [and] the progeny of animals".[138] On this line of reasoning, the human owner who owns the AI entity should be entitled to the ownership of the inventions it produces, *including* the right to apply for and own any patents granted for these inventions.[139]

The reader's attention is now drawn to *Thaler v Comptroller General of Patents, Trade Marks and Designs*, where Arnold LJ in the UK Court of Appeal held that the doctrine of accession applies only in situations where a piece of tangible property

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[132] See *eg*, Karl Popper, *The Logic of Scientific Discovery* (Milton Park: Taylor & Francis, 2005) at 276–281, where Popper argues that an increase in corroboration within the scientific arena will lead theories to advance toward higher levels of universality to tackle deeper and more general problems. See also Mimi Afshar, "I'm Not 'Human' After All – Can Artificial Intelligence Survive the Inventorship Requirement?" (2021) SSRN at 12 <https://ssrn.com/abstract=3792645>.

[133] Kitch, "The Nature and Function of the Patent System", *supra* note 76 at 275*ff*.

[134] "Artificial Inventors" in Abbott, *The Reasonable Robot, supra* note 100 at 88.

[135] *Ibid* at 87.

[136] See Peter Lee, "The accession insight and patent infringement remedies" (2011) 110(2) Mich L Rev 175 at 195; Thomas Merrill, "Accession and Original Ownership" (2009) J Legal Anal 459 at 460.

[137] See Earl Arnold, "The Law of Accession of Personal Property" (1922) 22 Colum L Rev 103 at 104.

[138] Simon Stern, *Oxford Edition of Blackstone's Commentaries on the Laws of England* (Oxford: Oxford University Press, 2016), Book II, ch 26 at 274 [Stern, *Oxford Edition of Blackstone's Commentaries*]. See also *Thaler v Comptroller General of Patents, Designs and Trade Marks*, *supra* note 24 at [49(3)(a)]; and *Thaler v Commissioner of Patents*, *supra* note 11 at [167].

[139] See *eg*, *PA (UK)*, *supra* note 24 s 7.

produces another piece of *tangible* property.[140] The learned judge observed that the crux of this doctrine is rooted in the concept of "dominion" or "exclusive possession" – the person who has exclusive possession of the "parent" property will generally be able to exercise exclusive possession over the property produced.[141] As such, where AI-generated inventions are concerned, the doctrine of accession is said to be inapplicable because a piece of tangible property (the AI entity) has produced a piece of *intangible* property – "an intangible of the kinds which are the subject-matter of intellectual property law"[142] – which is non-rivalrous and thus incapable of exclusive possession. Arnold LJ was of the view that exclusive possession of the intangible did not necessarily follow from exclusive possession of the tangible property that produced it. One example which was cited by the learned judge involves a person, A, who takes a digital photograph using B's camera. In this scenario, despite the fact that B owns the camera, the copyright in the photograph clearly belongs to A.[143]

With respect, however, this line of analysis faces several difficulties. In Arnold LJ's example, it is submitted that the doctrine of accession has no application whatsoever because the creation of the subsequent property – both tangible (the photograph) and intangible (the copyright subsisting therein) – is entirely attributable to the volitional acts of A, rather than the autonomous operation of B's camera. In the authors' view, a more appropriate analogy, for present purposes, is to consider a digital photograph taken *autonomously* by B's camera, *sans* any human intervention. It is unclear why, in that situation, the tangible nature of B's camera (over which B has exclusive possession) should preclude the attribution of (intangible) copyright ownership of the photograph to B. Indeed, the authors submit that there is no reason in principle why the rule of accession cannot be applied to intangible property rights that are *causally* derived from (or connected to) the intellectual output autonomously produced by tangible property. This line of thinking, it is further suggested, is particularly germane and cogent in cases where the creator/inventor of such intellectual output (such as an AI entity) is not a legal person capable of owning property.

Furthermore, it is highly arguable whether the doctrine of accession can *only* apply to "existing tangible property" producing "new tangible property". As Arnold LJ pointed out, Blackstone "did not suggest that the rule of accession applied to intangible property produced by tangible property, probably because such a possibility did not occur to him".[144] Yet, Blackstone did not explicitly confine the doctrine of accession to tangible property capable of exclusive possession.[145] It is submitted that this would have been Blackstone's obvious position since the idea of the *autonomous* creation of intangible property by tangible property could not, by any stretch of the imagination, have been contemplated at that time. On balance, the doctrine of

[140] *Thaler v Comptroller General of Patents, Trade Marks and Designs*, *supra* note 30 at [130]–[137].
[141] *Ibid* at [131].
[142] *Ibid* at [133].
[143] *Ibid* at [135].
[144] *Ibid* at [132].
[145] See Stern, *Oxford Edition of Blackstone's Commentaries*, *supra* note 138 at 274.

accession advocated by Blackstone is thus *neutral* in its potential application to the question of patent ownership of AI-generated inventions.

For all these reasons, the authors posit that the doctrine of accession (or at least the concepts distilled from this doctrine) may provide some useful support in granting patent ownership of AI-generated inventions to the owners of the AI entities. It might well be that "[t]his is really an argument about what the law should be, rather than about the present state of the law".[146] However, as Birss LJ has candidly acknowledged in respect of DABUS (and the authors respectfully agree), "[l]ooking at Dr Thaler's position as it stands [Dr Thaler being the owner of DABUS], it is not obvious that there is any other person with a better right than Dr Thaler's to be granted patents for these inventions".[147]

Apart from the rule of accession, another argument which might support Dr Thaler's position draws from notions within the law of agency. On this view, the AI entity – acting/inventing purely in a *representative* capacity – can be treated (in legal *fiction* if necessary) as the "agent" of its owner, who stands as the "principal".[148] The owner of the AI is therefore entitled to apply for patent ownership of the resulting AI-generated invention(s) produced on his behalf. Much like the human agent who has accomplished his duties but yet knows that he is disentitled to the ensuing benefits of the agreement he has brokered on behalf of his principal, the AI inventor ought to also fall out of the (patent entitlement) picture. It is conceded that AI inventors are not, in theory, *true* agents under the law because, *inter alia*, (a) they are not recognised as legal persons,[149] (b) it is unclear whether they have entered into the principal-agent relationship voluntarily,[150] and (c) they do not (at least in this context) alter their principals' legal positions vis-à-vis third parties. Nonetheless, despite these legal/technical limitations, the authors are of the view that a broad analogy with the doctrine of agency remains attractive in such a scenario.

Furthermore, the agency argument articulated here is, conceptually, no different from the principles that govern the employer-employee relationship,[151] where it is trite law that all inventions made by employees typically belong to the employer for the purposes of the patent statute and it is the employer who has the first right to apply for and obtain patents in respect of those inventions.[152] By virtue of the employer (and, by extension, the principal) assuming a position of *ascendancy* vis-à-vis the employee (and, by extension, the agent), it is not unreasonable to suggest that patent law should likewise allow the principal (that is, someone other than the putative inventor) to stand in the place of the agent-inventor with respect to the right

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146 *Thaler v Comptroller General of Patents, Trade Marks and Designs*, *supra* note 30 at [136].

147 *Ibid* at [85].

148 *Cf Thaler v Commissioner of Patents*, *supra* note 11 at [167]: "Dr Thaler is the owner, programmer and operator of DABUS, the artificial intelligence system that made the invention; in that sense *the invention was made for him*. On established principles of property law, he is the owner of the invention." [emphasis added]

149 Seng & Tan, "Artificial Intelligence and Agents", *supra* note 23 at [10].

150 Gino Dal Pont, *Law of Agency*, 3d ed (New York: LexisNexis Butterworths, 2014) at 5–6.

151 In any event, it is well known that an employee becomes an agent for the employer where there has been a conferral of authority to alter or affect the employer's legal relations with third parties: see Peter Watts & FMB Reynolds, eds, *Bowstead and Reynolds on Agency*, 22nd ed (London: Sweet & Maxwell, 2021) at [1-004].

152 See, respectively, *PA (UK)*, *supra* note 24 ss 39(1), 7(2)(*b*).

to apply for and obtain a patent (and reap the resulting economic benefits accordingly), even though the agent-inventor would otherwise be entitled to apply.[153] Indeed, it appears to the authors that such an argument has even greater force where the agent-inventor in question is a non-human (such as an AI entity), in light of the unquestionable dominion/dominance exercised by the principal (namely, the owner of the AI entity) over the non-human agent (one that simply performs, in the absence of discretion, an entirely *ministerial* function – which is to invent autonomously).

Finally, the authors observe that the UKIPO has also considered the option of granting patent ownership of AI-generated inventions to the "human who made the arrangements necessary for AI to devise the invention" (classed by the UKIPO in its public consultation paper as "Option 2"),[154] once again drawing upon copyright law for inspiration. This approach appears, at first glance, to present a fairer outcome, particularly in tricky scenarios where the owner of the AI entity may not have been the person who undertook the various arrangements necessary for these AI-generated inventions to materialise. One might therefore argue that it may be more appropriate in such cases to grant patent ownership to the person(s) "closely" (or truly) "responsible" for making the arrangements necessary for the AI to devise such inventions – such as the person(s) who funded the creation and development of the AI entity and who may have contractually engaged and remunerated the relevant experts in the field (for example, to programme or configure the AI, select input/training data for the AI, train the AI and/or operate/use the AI). However, it bears emphasising that granting patent ownership to the AI entity's *owner* as a *default* rule remains the authors' preferred option, because (a) it provides for greater certainty and consistency, (b) it reflects commercial reality, and (c) this approach would conduce more to conceptual clarity.

First, granting patent ownership to the owners of AI entities will circumvent the dilemma of having to decide who the "human who made the arrangements necessary for AI to devise the invention" is. Given that numerous other individuals may well be involved in the creation and subsequent development of the AI entity, it might be difficult for the courts to determine precisely who should be deemed to have undertaken the necessary arrangements. While this assessment is highly fact-sensitive and largely based on common sense,[155] specific criteria or guidelines may need to be formulated in due course (either by Parliament or the courts) as the number of individuals involved in the creation and maintenance of complex AI entities will likely increase over time. It appears, in this regard, that the touchstone

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[153] See also *Thaler v Comptroller General of Patents, Designs and Trade Marks*, *supra* note 24 at [45(3)(d)(i)]: "Given that the employee will typically be a natural person and the employer typically a legal person, these sections seem to me to underline that the inventive concept is very much a matter arising from the mind of a natural person, whilst *the economic benefits of the invention pass to another, in this case the employer*." [emphasis added]

[154] See UKIPO, "Artificial Intelligence and Intellectual Property", 29 October 2021, *supra* note 8. Under "Option 2", one of the recommendations is to amend the patent statute "to allow AI to be named as the inventor" and for the "human closely responsible for an invention devised by AI" to "own the patent rights in the first instance".

[155] See *Slater v Wimmer* [2012] EWPCC 7 at [80]. See also *Beggars Banquet v Carlton Television* [1993] EMLR 349 at 361.

is that of control,[156] although it remains a truism that the devil is clearly in the details. It is therefore preferable, in the authors' view, to grant patent ownership of AI-generated inventions to the owners of the AI *in the first instance*. This default rule will foster greater legal and commercial *certainty* and also allow the owners of these entities to bolster their patent portfolios, thereby incentivising even greater procurement of (and investment in) AI technology.[157]

Secondly, the authors' preferred option accords with *commercial reality*. This is because in the vast majority of cases, the owners of the AI entities – such as individuals or, more likely, corporate entities with deep pockets – will likely be the ones to make all the arrangements necessary for the AI to devise the invention. Large sums of investment are typically required to fund such arrangements,[158] and thus it is unlikely that the other parties involved in the developmental process (such as the designers, developers, and data scientists) will assert that they were "closely" involved in making such arrangements. Moreover, the owner of the AI entity (who may not have the requisite expertise) will likely be required to make *contractual* arrangements with these other parties (or experts in their respective fields) to engage and remunerate them for their work, as well as to ensure, for the avoidance of doubt, that the ownership of any subsequent patent(s) will vest in the former. Given this reality, the UKIPO's Option 2 and the authors' preferred approach are likely to lead to the same outcomes in practice in any event.

Thirdly, it is submitted that there will be greater *conceptual clarity* and *coherence* in granting patent ownership to the AI entity's owner, rather than to the "human who made the arrangements necessary for AI to devise the invention". As patent ownership is (at least initially or "primarily") tied to inventorship,[159] first ownership of the patent typically vests in the inventor.[160] Yet, in the absence of legal personhood being accorded to AI entities (an issue of contention that is beyond the scope of this article), it is imperative to identify a *legal person* as the patent *owner* of an AI-generated invention. To this end, the various doctrinal arguments canvassed above – such as those on the rule of accession and analogous to principles of agency law – provide a reasonably sound conceptual basis to justify why patent ownership ought to vest in the owner of the AI entity.

In light of the foregoing discussion, the authors maintain that patent ownership of AI-generated inventions should vest in the owners of the AI entities in the first instance. Nevertheless, it is suggested that this default position can always be *modified* by contract (for instance, an assignment) so as to further various other commercial goals. In other words, individuals who are not the AI entity's owner but who wish to finance the AI entity's creation, development, operation, or processes, or

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156 Lim, "AI & IP", *supra* note 26 at 843.

157 See Fraser, "Computers as Inventors", *supra* note 27 at 331.

158 See *eg*, Statista, "Global total corporate artificial intelligence (AI) investment from 2015 to 2020" <https://www.statista.com/statistics/941137/ai-investment-and-funding-worldwide/>. See also Hilty, Hoffmann & Scheuerer, "Intellectual Property Justification for Artificial Intelligence", *supra* note 41 at 71 ("[p]otential protection regimes – if ever required – would be looking not at creators or inventors, but at investors").

159 See Fraser, "Computers as Inventors", *supra* note 27 at 331; *PA (UK)*, *supra* note 24 s 7(2)(a).

160 *Beech Aircraft Corp v EDO Corp*, *supra* note 72 at 1248 ("the patent right initially vests in the inventor who may then, barring any restrictions to the contrary, transfer that right to another, and so forth").

undertake any other commercial activity (or "necessary" arrangements) relating to the AI entity, ought to be aware that patent ownership will, by default, vest in the AI entity's owner. The onus will therefore be on these other parties to enter into appropriate contractual arrangements with the AI entity's owner to ensure that they are either adequately remunerated or accorded patent ownership through an assignment from the owner. Otherwise, in order to dispute ownership, they have to be prepared to challenge the owner's entitlement to the grant of a patent in separate entitlement proceedings.[161]

IV. Conclusion

The challenges which fully autonomous AI inventors will invariably pose to long-standing tenets of patent law cannot be discounted, or worse, completely ignored. Pertinently, innovative activity and output that emanate from "creative machines" (and far beyond the confines of the human mind) will, sooner rather than later, demand a judicious reconsideration of traditional notions of inventorship. This will, in turn, have significant implications for the patentability of AI-generated inventions and the ensuing allocation of patent ownership rights for such inventions. To complicate matters, the difficulties in formulating workable solutions to these problems are further compounded by worries of, on the one hand, unfounded prejudice to human inventors (and their inventions) and, on the other, the law drawing indefensible distinctions between AI and human inventors.

The authors have sought in this article to examine whether existing patent law frameworks can sensibly accommodate present and future developments in AI technology on the specific questions of inventorship and patent ownership. Because fully autonomous AI entities and AI-generated inventions will appear on the horizon in the not too distant future, Parliaments must act timeously to ensure that patent statutes remain future-proof and capable of meeting patent law's underlying objectives (such as to encourage innovation and disseminate knowledge) in *all* deserving cases. The authors have made two recommendations in this regard.

First, it has been argued that patent legislation ought to expand the concept of inventorship to encompass fully autonomous AI inventors – to (a) acknowledge the reality that for AI-generated inventions, it is really the machine inventor (and not any identifiable natural person) that has undertaken all (qualitatively significant) aspects of the inventive process, and (b) safeguard the moral/ethical principles associated with inventorship. Such an approach is also desirable from a policy perspective as it prevents inventions that would otherwise satisfy the stringent requirements of patentability from falling outside the purview of patent protection on the sole basis that there is no identifiable human inventor. Being unable to patent AI-generated inventions would clearly discourage the disclosure of such inventions, disincentivise further investments in (and adoption of) AI technology, and (as Beach J quite rightly put it) constitute "the antithesis of promoting innovation".[162]

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[161] See *Thaler v Comptroller General of Patents, Trade Marks and Designs*, *supra* note 30 at [47(iv)], [83].
[162] *Thaler v Commissioner of Patents*, *supra* note 11 at [132] (and see also [134]).

Second, it is submitted that the owners of the AI entities ought to be conferred the right to apply for and obtain patent rights in respect of all AI-generated inventions. This default rule will, as explained, ensure that incentives to further invest in AI technology are not only adequately *provided* (in the guise of patent ownership), but also appropriately *targeted* at the right stakeholders. Other advantages include the legal/commercial certainty and tenable doctrinal underpinnings that come with this approach.

Ultimately, patent law serves to benefit society by, for instance, promoting "the progress of science and the useful arts",[163] thereby leading to a net increase in the pool of socially useful products and processes. The authors posit that the advent of AI in no way undermines these values and goals. On the contrary, AI technology has the potential to add exponentially to the stock of existing scientific knowledge and generate inventions that will substantially improve the lives of humankind.[164] Patent law, however, must not stand in the way of this nascent phenomenon but should instead regard AI inventors – as much as human inventors – as *opportunities* to be harnessed, rather than as *threats* to be denounced. Difficult questions, such as those raised in this article, must be squarely confronted and addressed at the earliest opportunity. Undoubtedly, AI technology is currently perched on the threshold of promising new frontiers. Humanity will be poorer for it if the law were to ignore this patent reality!

[163] US Constitution Art I § 8 cl 8.

[164] See *eg*, Yuan Liang, Lei He & Xiang Anthony Chen, "Human-Centered AI for Medical Imaging" in Yang Li & Otmar Hilliges, eds, *Artificial Intelligence for Human Computer Interaction: A Modern Approach* (New York: Springer, 2021) at 541–544.