Intellectual Property Office

BL O/935/22
27 October 2022

PATENTS ACT 1977

APPLICANT	1QB Information Technologies Inc.
ISSUE	Whether patent applications GB1819448.0 complies with section 1(2) of the Act
HEARING OFFICER	H Jones

DECISION

Background

1 Patent application GB1819448.0 was filed on 9 May 2017 via the PCT route in the name of 1QB Information Technologies Inc. and has a priority date of 9 May 2016. The international application was published as WO2017/195114 A1 on 16 November 2017 and subsequently as GB2569702 A. The application was searched while in the international phase.

2 The original 'compliance period', that is the period by the end of which the application needs to comply with all the requirements of the Patents Act 1977 ("the Act") and the rules, ended on 30 June 2022. This period was extended to by two months to end on 30 August 2022.

3 Throughout the examination process, the examiner objected that this application relates to a computer program and a mathematical method, thus is therefore excluded from patentability. Despite several rounds of correspondence and amendments to the claims, the applicant's attorney, Mr Daniel Shaw of Pearl Cohen, has not been able to persuade the examiner otherwise. The examiner consequently offered a hearing, and the applicant has requested a decision based on the correspondence on file.

4 Two sets of amended claims (a 'main request' and an 'auxiliary request') and accompanying argument were file by Mr Shaw on 13 June 2022.

5 The issue to be decided is whether the invention consists solely of a program for a computer and/or a mathematical method which the Act excludes from patentability under section 1(2)(c). My reasoning considers the arguments presented for both the main and auxiliary requests.

The invention

6 The application relates to improving a policy for a stochastic control problem, in particular Markov decision processes. Markov decision processes are widely used to model sequential decision making under uncertainty, and are involved in many

stochastic control problems such as financial portfolio optimisation, industrial equipment replacement, generating sports strategies etc.

7 A stochastic control problem is characterised by decision epochs, actions, states, a discount factor and a reward structure. A policy in this sense is the assignment of an action to a state of a system at each decision epoch. In the example of industrial equipment replacement, a policy may be to replace the equipment only when it is in a failing condition. Finding an optimal policy for a problem is tricky when problem sizes are large. The application aims to overcome this through the implementation of a Boltzmann Machine using a computing system comprising a digital computer and a quantum computer. Particular advantages of the invention are discussed in the description and have been expanded upon in correspondence from the applicant's attorney; these are the provision of a faster method of Q-learning in quantum sampling and overcoming the large data requirements of high dimensionality.

8 The method of the application is carried out on a computer, and the disclosed approach to quantum sampling relates to the specific detail of how the calculation uses a conventional digital/quantum system.

9 Both the main request and the auxiliary request include independent claims to a method, a digital computer and a computer program, but they do not differ in substance. I will first consider claim 1 of the main request, with the auxiliary request being considered later.

MAIN REQUEST

10 Claim 1 reads as follows:

> A method for improving a policy for a stochastic control problem, the stochastic control problem being characterized by a set of actions, a set of states, a reward structure as a function of states and actions, and a plurality of decision epochs, wherein evolution of an underlying stochastic state process depends on a plurality of actions in a policy, the method comprising:
>
> using a quantum processor coupled to a digital computer and to a quantum device control system, the quantum processor obtaining data representative of sample configurations of a general Boltzmann machine comprising:
>
> a plurality of qubits arranged into a first group of qubits representative of visible nodes of the Boltzmann machine and a second group of qubits representative of hidden nodes of the Boltzmann machine,
>
> a plurality of couplers including:
>
> at least one coupler for providing a communicative coupling at a crossing between a qubit of the first group of qubits and at least one qubit of the second group of qubits, and
>
> a plurality of couplers for providing a communicative coupling at a crossing between a qubit of the second group of qubits and other qubit in the second group of qubits,

a plurality of biases, each bias corresponding to a qubit in the plurality of qubits,

a plurality of coupling weights, each coupling weight corresponding to a coupler of the plurality of couplers, and

a transverse field strength;

obtaining, using the digital computer, initialization data comprising the set of actions, the set of states, the reward structure of the stochastic control problem and an initial policy for the stochastic control problem, the policy comprising a choice of at least one action for each state;

using the digital computer and the quantum device control system, assigning data representative of an initial weight and a bias of respectively each coupler and each qubit and the transverse field strength of the Boltzmann machine to the quantum processor;

until a stopping criterion is met:

generating a present-epoch state-action pair using the digital computer,

using the digital computer and the quantum device control system, amending data representative of at least one coupler and at least one bias using the generated present-epoch state-action pair by switching all couplers providing a communicative coupling at a crossing between a qubit of the first group of qubits and the second group of qubits OFF, and updating the biases of the hidden nodes in the second group of qubits that are coupled to visible nodes in the first group of qubits using the generated present-epoch state-action pair,

performing a sampling corresponding to the present-epoch state-action pair to obtain first sampling empirical means,

obtaining, using the first sampling empirical means, using the digital computer, an approximation of a value of a Q-function at the present-epoch state action, the value of the Q-function being representative of a utility of the present epoch state-action pair,

obtaining, using the digital computer, a future-epoch state-action pair, wherein the state is obtained through a stochastic state process, and further wherein the obtaining of the action comprises performing a stochastic optimization test on the plurality of all state-action pairs comprising the future-epoch state and any possible action to thereby provide the action at the future-epoch,

updating the current policy for the future-epoch state with the obtained future-epoch action,

amending, using the digital computer and the quantum device control system, data representative of at least one coupler and at least one bias using the generated future-epoch state-action pair by switching all couplers providing a communicative coupling at a crossing between a qubit of the first group of qubits and the second group of qubits OFF, and updating the biases of the

hidden nodes in the second group of qubits that are coupled to visible nodes in the first group of qubits using the generated future-epoch state-action pair,

performing a sampling corresponding to the future-epoch state-action pair to obtain second sampling empirical means,

obtaining, using the second sampling empirical means, using the digital computer, an approximation of a value of the Q-function at the future-epoch state-action, the value of the Q-function being representative of a utility of the futureepoch state-action pair, and

using the digital computer, updating each weight and each bias of respectively each coupler and each qubit of the Boltzmann machine using the generated approximations of the value of the Q-function and the first sampling empirical means at present-epoch state-action pair and a corresponding reward at the present-epoch state-action pair obtained using the reward structure; and

providing the policy using the digital computer when the stopping criterion is met by displaying the policy to a user interacting with the digital computer.

The law

11 The examiner has raised an objection that the invention is not patentable because it relates to one or more of the categories of subject-matter which are not considered to be inventions under the Act. This 'excluded matter' is set out in section 1(2) of the Act:

> *1(2). It is hereby declared that the following (among other things) are not inventions for the purposes of this Act, that is to say, anything which consists of –*
>
> *(a) a discovery, scientific theory or mathematical method;*
>
> *(b) a literary, dramatic, musical or artistic work or any other aesthetic creation whatsoever;*
>
> *(c) a scheme, rule or method for performing a mental act, playing a game or doing business, or a program for a computer;*
>
> *(d) the presentation of information;*
>
> *but the foregoing provision shall prevent anything from being treated as an invention for the purposes of this Act only to the extent that a patent or application for a patent relates to that thing as such.*

12 The Court of Appeal's judgement in *Symbian*[1] tells us that in order to determine whether an invention falls solely within the any of the exclusions listed in section 1(2), the four-step test set out in its earlier judgement in *Aerotel*[2] must be used. The four steps are:

(1) properly construe the claim(s);

(2) identify the actual (or alleged) contribution;

(3) ask whether it falls solely within the excluded subject-matter;

[1] Symbian Ltd. v Comptroller-General of Patents [2008] EWCA Civ 1066
[2] Aerotel Ltd v Telco Holdings Ltd and Macrossan's Application [2006] EWCA Civ 1371

(4) check whether the actual or alleged contribution is actually technical in nature.

13 The fourth step of the test is to check whether the contribution is technical in nature. In paragraph 46 of *Aerotel* it is stated that applying this fourth step may not be necessary because the third step should have covered the question. I shall consider whether the contribution is excluded alongside the question of whether the contribution is technical in nature, meaning I will consider the third and fourth steps of *Aerotel* together.

14 To assist in identifying whether there is a technical contribution in computer related inventions, the signposts set out in *AT&T/CVON*[3] and by the Court of Appeal in *HTC/Apple*[4] act as guidelines. They provide a list of some of the factors that can indicate whether a contribution may be technical. They are:

i) whether the claimed technical effect has a technical effect on a process which is carried on outside the computer;

ii) whether the claimed technical effect operates at the level of the architecture of the computer; that is to say whether the effect is produced irrespective of the data being processed or the applications being run;

iii) whether the claimed technical effect results in the computer being made to operate in a new way;

iv) whether the program makes the computer a better computer in the sense of running more efficiently and effectively as a computer;

v) whether the perceived problem is overcome by the claimed invention as opposed to merely being circumvented.

Argument and analysis

Step 1 - Properly construe the claim

15 The detail of claim 1 has been considered carefully by the examiner throughout the examinations process, and specifically in relation to the amended claims in his report of 20 May 2022. At no point in the examination process has Mr Shaw challenged the examiner's construction of the claims. I am in agreement with the examiner that in essence claim 1 can be construed as the following:

Operating a computing system comprising a digital computer and a quantum computer with a given qubit arrangement implementing a Boltzmann Machine which receives a policy of a stochastic control problem and provides an improved policy as an output by initialising and performing an optimisation algorithm on the computing system.

[3] AT&T Knowledge Venture/CVON Innovations v Comptroller General of Patents [2009] EWHC 343 (Pat)
[4] HTC Europe Co Ltd v Apple Inc [2013] EWCA Civ 451

Step 2 – Identify the actual (or alleged) contribution

16 Paragraph 43 of *Aerotel* suggests that the contribution is, in essence, that which has been added to the stock of human knowledge. Determining the contribution involves taking into account the problem to be solved, how the invention works and what the advantages are. It also involves looking at the substance and not the form of the claims. It involves looking beyond the literal wording of the claims to consider the central idea embodied in the claims.

17 The examiner has made extensive discussion and consideration of the individual processing steps in claim 1 when attempting to define the contribution, with his final analysis being set out in para 15 of his report of 20 May 2022. However, I am of the view that the contribution can be defined slightly more broadly, to avoid any risk of obscuring the overarching contribution with precise detail. I therefore consider the contribution to be as follows:

A method of improving a policy for a Stochastic Control Problem, with the advantages of computationally faster Q-learning and obviating extreme data requirements in high dimensionality computations, by executing an algorithm on a system comprising a digital computer and a quantum computer, the algorithm causing the system to be operated with a specific qubit and couplers arrangement to represent and implement a General Boltzmann Machine.

Steps 3 & 4 - Whether the actual or alleged contribution falls solely within the excluded matter and check whether it is actually technical

Computer program

18 In considering whether the above contribution is technical, I will use the above-mentioned signposts which provide a list of some of the factors that can indicate whether a contribution may be technical in computer related inventions.

Signpost i): whether the claimed technical effect has a technical effect on a process which is carried on outside the computer

19 To meet the first signpost, the process carried out by the program must be, or must operate on, something external to the computer on which the program is being run.

20 Mr Shaw argues in his letter of 5 May 2022 (and maintained in his letter of 13 June 2022) that, and I paraphrase, the claimed invention provides an arrangement into which a user feeds a problem and receives a solution/improvement via a display. It is argued that this constitutes a technical effect on a process carried on outside the computer, irrespective of what the policy may relate to.

21 While I agree that the effect of the program here is the provision of an improved policy, the claim is broad enough to cover a policy in non-technical fields such as finance. I agree with the examiner that the computer-implemented invention is not tied to a technical process outside the computer and so signpost i) is not met.

Signpost ii): whether the claimed technical effect operates at the level of the architecture of the computer; that is to say whether the effect is produced irrespective of the data being processed or the applications being run;

22 The identified contribution specifies that the algorithm causes the quantum computer to be operated with a specific qubit and couplers arrangement in order to represent and implement a General Boltzmann Machine (GBM).

23 I have considered Mr Shaw's argument in his letters of 5 May 2022 and 13 June 2022, which in essence asserts that the contribution provides a technical effect at the level of the architecture of the system. In particular, that "the algorithm defines a totally different approach to exploiting various system components, notably qubits and couplers, such that the internal functioning of the system is varied with respect to the existing state of the art", and that "the contribution lies in a material variation in the manner in which the system physically processes data at an architectural level". They further argue that my comments as the Hearing Officer at para 19 of Office Decision BL O/347/10 (which I believe was intended to be referred to rather than BL O/347/20) support their opinion. I am not convinced that these comments are of use here. I share the examiner's view that specific way in which the quantum computer is operated is entirely dictated by the specific program requirements, as opposed to methods of operating the hardware having general applicability. Put another way, the contribution relates to programming a quantum computer to implement a GBM rather than reconfiguring the computer architecture at the hardware level.

24 The operation of the quantum computer with the specific qubit and couplers arrangement is determined entirely by the program being run. I am not persuaded that this has any technical effect at the level of the architecture within the meaning of this signpost. Signpost ii) is therefore not met.

Signpost iii): whether the claimed technical effect results in the computer being made to operate in a new way;

Signpost iv): whether the program makes the computer a better computer in the sense of running more efficiently and effectively as a computer;

25 I will consider signposts iii) and iv) together. It is my view, in light of the discussion of signpost ii) above, that the contribution is a program that runs on known hardware, the program itself determining the operation of the quantum computer with a specific qubit and couplers arrangement to execute the program in a more effective way with the advantages stated. The operation of the quantum computer in this way does not make the computer a better computer for general applications beyond the specific execution of the program.

26 Thus signposts iii) and iv) are not met.

Signpost v): whether the perceived problem is overcome by the claimed invention as opposed to merely being circumvented.

27 The problems to be overcome by the claimed invention are defined in the advantages set out in the contribution, those of computational speed of Q-learning and extreme data requirements in high dimensionality computations. These problems lie with the processing rather than the hardware, and are solved by providing an improved program which is able to be executed more effectively.

28 Mr Shaw argues in his letter of 13 June 2022 that "the algorithm defines a totally different approach to exploiting the various system components, notably qubits and couplers, such that internal functioning of the system is varied with respect to the

state of the art" and that the invention overcomes the problems "…by way of an improved utilisation of a known computer system arrangement at an architectural level…"

29 Given my view in relation to signpost ii) that there is no technical effect at the level of the architecture here, this suggests that it is the program that is utilising the system more effectively. Therefore, I agree with the examiner that the claimed invention provides a better program in order to overcome hardware limitations (the claimed invention relates to the how the hardware is programmed, not how its architecture is configured), and thus circumvents rather than solves the stated problems. Thus, signpost v) is not met.

30 I therefore conclude that the invention claimed in the main request is excluded as a program for a computer as such under section 1(2)(c).

Mathematical method

31 The invention claimed in the main request contribution relates to the execution of an algorithm to improve a policy for a Stochastic Control problem. It is therefore also excluded as a mathematical method as such under section 1(2)(a).

AUXILIARY REQUEST

32 The only difference between the claims of the main and auxiliary requests is that the main request specifies a "General Boltzmann Machine" while the auxiliary request specifies an "unrestricted General Boltzmann Machine".

Added matter and patentability

33 Mr Shaw's letter of 13 June 2022 sets out that the auxiliary request is implicitly disclosed, but the examiner disagrees suggesting the inclusion of an "unrestricted" GBM is not supported and thus adds matter. I have not considered the issue of added matter in detail, because in my opinion, whether or not added matter is present, the auxiliary request does not save the claimed invention from exclusion. Moving from one type of GBM to another does not affect the above arguments and so does not result in a technical contribution.

34 For completeness, I therefore conclude that the invention claimed in the auxiliary request is excluded as a program for a computer as such under section 1(2)(c) and as a mathematical method as such under section 1(2)(a).

Conclusion

35 Having carefully considered the arguments, I am of the view that the claimed invention is excluded by section 1(2) both as a program for a computer as such and as a mathematic method as such. I therefore refuse the application under section 18(3).

Appeal

36 Any appeal must be lodged within 28 days after the date of this decision.

Huw Jones
Deputy Director, acting for the Comptroller