



DATED 24/2/17

THE CHANCELLOR MASTERS AND SCHOLARS OF THE
UNIVERSITY OF OXFORD

and

UNIVERSITY OF PORTSMOUTH HIGHER EDUCATION
CORPORATION

ACADEMIC COLLABORATION AGREEMENT

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THIS AGREEMENT is made on _____ 2017 BETWEEN:

- (1) **THE CHANCELLOR MASTERS AND SCHOLARS OF THE UNIVERSITY OF OXFORD**, whose administrative office is at University Offices, Wellington Square, Oxford, OX1 2JD ("**Oxford**"); and
- (2) **UNIVERSITY OF PORTSMOUTH HIGHER EDUCATION CORPORATION**, whose address is at University House, Winston Churchill Avenue, Portsmouth PO1 2UP ("**Portsmouth**"),

each a "**Party**" and collectively the "**Parties**".

BACKGROUND

- (A) Oxford is the sponsor of a clinical study entitled "Towards preventing foetal brain injury at term while reducing the rate of emergency deliveries: making use of large datasets of foetal heart rate monitoring".
- (B) The clinical study involved the collection of data from term deliveries
- (C) The Parties wish to carry out the collaborative research project described in Schedule 1, which involves the analysis of data including digital CTG of labours and information about labour outcome.
- (D) The Parties wish to record in this Agreement the terms and conditions under which the Parties will conduct the collaboration and Oxford will supply data to Portsmouth.

NOW IT IS AGREED as follows:

1. DEFINITIONS AND INTERPRETATION

- 1.1 The following expressions, when used in this Agreement, shall have the meanings given to them in this Clause 1.1:

"Academic and Research Purposes" means research, teaching or other scholarly use which is undertaken for the purposes of education and research;

"Allocated Work" means the research allocated to each Party, as set out in Schedule 1 to this Agreement;

"Arising Intellectual Property" means any Intellectual Property which is generated by either Party directly as a result of the work undertaken in accordance with this Agreement;

"Background Intellectual Property" means any Intellectual Property excluding Arising Intellectual Property owned or controlled by either Party prior to commencement of or independently from the Project, and which the owning Party contributes or uses in the course of performing the Project;

"Confidential Information" means any and all confidential information (however recorded, preserved or disclosed), including but not limited to the Data, disclosed by

a Party to the other Party in connection with the Project and clearly identified as “confidential” at the time of disclosure (or, if disclosed orally, identified as “confidential” at the time of disclosure and confirmed as such in writing within thirty (30) days of such oral disclosure) or written, prepared or generated in the course of, and as part of, the Project; any Background Intellectual Property disclosed by one Party to the other for use in the Project and any Arising Intellectual Property in which that Party owns the Intellectual Property;

“**Portsmouth Investigator**” means **Dr Ivan Jordanov, Reader, School of Computing, University of Portsmouth**;

“**Oxford Investigator**” means **Dr Antoniya Georgieva, Nuffield Department of Obstetrics and Gynaecology, The Chancellor, Masters and Scholars of the University of Oxford**;

“**Effective Date**” means the date on which this Agreement is made;

“**Intellectual Property**” means any patents, rights to inventions, copyright and related rights, rights in designs, database rights, and all other intellectual property rights, in each case whether registered or unregistered and including all applications, and rights to apply for and be granted renewals or extensions of, and rights to claim priority from, such rights and all similar or equivalent rights or forms of protection which subsist or will subsist now or in the future in any part of the world;

“**Licensed Data**” means the data which Oxford will transfer to Portsmouth under this Agreement, as set out in Schedule 1 and as described in Schedule 2;

“**Project**” means the project described in Schedule 1, as amended from time to time with the prior written agreement of the Parties; and

“**Study**” means the clinical study entitled: “Towards preventing fetal brain injury at term while reducing the rate of emergency deliveries: making use of large datasets of foetal heart rate monitoring”.

1.2 In this Agreement:

1.2.1 the headings are used for convenience and shall not affect its interpretation;

1.2.2 a reference to this “**Agreement**” shall include the Schedules;

1.2.3 if there is an inconsistency between any of the provisions in the main body of this Agreement and the Schedules, the provisions in the main body of this Agreement shall prevail;

1.2.4 unless the context otherwise requires, words in the singular shall include the plural and in the plural shall include the singular;

1.2.5 a reference to a statute or statutory provision is a reference to it as amended, extended or re-enacted from time to time and shall include all subordinate legislation made from time to time under that statute or statutory provision;

- 1.2.6 a reference to writing or written includes fax but not e-mail;
- 1.2.7 references to clauses and Schedules are to the clauses and Schedules of this Agreement; and
- 1.2.8 any words following the terms including, include, in particular, for example or any similar expression shall be construed as illustrative and shall not limit the sense of the words, description, definition, phrase or term preceding those terms.

2. THE PROJECT

- 2.1 The Parties will each use their reasonable endeavours to collaborate on the Project.
- 2.2 The Project shall be performed by or under the direction and supervision of the Oxford Investigator and the Portsmouth Investigator.
- 2.3 In respect of the Allocated Work, each Party will use its reasonable endeavours to provide adequate facilities; to obtain any requisite materials, equipment and personnel; and to carry out the work diligently within the scope allowed by its funding. Although each Party will use its reasonable endeavours to perform the Project, no Party undertakes that work carried out under or pursuant to this Agreement will lead to any particular result, nor is the success of such work guaranteed.

3. DATA TRANSFER

- 3.1 In consideration of the obligations accepted by Portsmouth under this Agreement, Oxford grants to Portsmouth during the Term a non-exclusive, personal and non-transferable licence of the Licensed Data and the Updates strictly for Project.
- 3.2 Where applicable, risk in the physical media (if any) on which any Licensed Data or any of the Updates are recorded shall pass to Portsmouth on delivery. Without prejudice to any other provision of this Agreement, Portsmouth shall be solely responsible and primarily liable for all use of the Licensed Data and/or Updates provided to Portsmouth.
- 3.3 Portsmouth must not:
 - 3.3.1 use the Licensed Data and/or the Updates other than for the Project in strict conformity with this Agreement and any other reasonable instructions of Oxford;
 - 3.3.2 except for the Project (or as permitted by law) alter, modify, adapt, delete, add to or translate the whole or any part of the Licensed Data or any of the Updates, nor permit the whole or any part of the Licensed Data or any of the Updates to be combined with or become incorporated with any other data or within any other computer program(s) or database of any kind, nor decompile, disassemble or reverse engineer the same nor attempt (or permit any third party to attempt) to do any such thing;

- 3.3.3 except as may be strictly necessary for carrying out the Permitted Purpose, provide or otherwise make available Licensed Data or any of the Updates to any third party or allow use of it or them by or on behalf of any third party, in whole or in part, whether by way of sale, resale, loan, transfer, hire or any other form of exploitation;
 - 3.3.4 unless otherwise expressly agreed in writing by Oxford, make Licensed Data or any of the Updates (or allow either of the same to be made) available online, in whole or in part, via the internet or on any intranet;
 - 3.3.5 attempt to identify any identifiable living or deceased individual from the Licensed Data.
- 3.4 Portsmouth shall be responsible for ensuring that it has (and for configuring) the telecommunications and other equipment and software (including security and virus-checking software), with appropriate licences, necessary in order safely and securely to receive, access and use the Licensed Data and any Updates for the Permitted Purpose.
- 3.5 Portsmouth shall:
 - 3.5.1 comply with all applicable laws and regulations from time to time in relation to the use of the Licensed Data and/or the Updates;
 - 3.5.2 not by itself or with others participate or encourage the participation in any illegal, deceptive, misleading or unethical practice, including, but without limitation, disparagement of the Licensed Data and the Updates or any other practices which may be detrimental to the same or Oxford; and
 - 3.5.3 notify Oxford promptly of any inaccuracies, errors or malfunctions in the Licensed Data or the Updates which come (or should reasonable come) to its attention.
- 3.6 All rights not expressly granted to the Data User under this Agreement are reserved to the University and/or its third party licensors, and the Data User shall make no use of the Licensed Data except as expressly permitted by this Agreement. The Data User shall permit the University to take such steps as the University reasonably considers appropriate to monitor compliance with the terms of this Agreement, and shall co-operate fully with the University in relation to such monitoring.
- 3.7 Portsmouth understands that the Data is experimental in nature, and that Oxford makes no representations and gives no warranties of any kind in relation to it: for example, no warranties are given about quality or fitness for a particular purpose; or that the use of the Data will not infringe any intellectual property or other rights.
- 3.8 Nothing included in this Agreement shall prevent Oxford from being able to distribute the Data to other commercial or non-commercial entities.

3.9 The Parties shall (and shall ensure that their respective Representatives shall) comply with the requirements of the Data Protection Act 1998 (and related legislation) in conducting the Project or otherwise in connection with this Agreement.

4. PUBLICATION AND CONFIDENTIALITY PROCEDURES

4.1 Subject to Clauses 4.4 and 4.5, each Party will use all reasonable endeavours not to disclose to any third party any Confidential Information nor use for any purpose except as expressly permitted by this Agreement, any of the other Party's Confidential Information.

4.2 No Party shall incur any obligation under Clause 4.1 with respect to Confidential Information which:

4.2.1 is known to the receiving Party before the Effective Date, and not impressed already with any obligation of confidentiality to the disclosing Party;

4.2.2 is or becomes publicly known without the fault of the receiving Party;

4.2.3 is obtained by the receiving Party from a third party in circumstances where the receiving Party has no reason to believe that there has been a breach of an obligation of confidentiality owed to the disclosing Party;

4.2.4 is independently developed by the receiving Party;

4.2.5 is approved for release in writing by an authorised representative of the disclosing Party; or

4.2.6 the receiving Party is specifically required to disclose in order to fulfil an order of any Court of competent jurisdiction provided that, in the case of a disclosure under the Freedom of Information Act 2000, none of the exemptions in that Act applies to the Confidential Information.

4.3 If either Party receives a request under the Freedom of Information Act 2000 to disclose any Confidential Information, it will notify and consult with the other Party. The other Party will respond within five working (5) days after receiving notice if the notice requests assistance in determining whether or not an exemption in that Act applies.

Publications

4.4 This Agreement shall not prevent or hinder registered students of either Party from submitting for degrees of that Party theses based on results obtained during the course of work undertaken as part of the Project; or from following that Party's procedures for examinations and for admission to postgraduate degree status.

4.5 In accordance with normal academic practice, all employees and students of the Parties who work on the Project shall be permitted:

- 4.5.1 following the procedures laid down in Clause 4.6, to publish results, jointly where applicable, obtained during the course of work undertaken as part of the Project; and
- 4.5.2 in pursuance of the Parties' academic functions, to discuss work undertaken as part of the Project in internal seminars and to give instruction within their organisation on questions related to such work.
- 4.6 Each Party will use all reasonable endeavours to submit material intended for publication to the other Party in writing not less than thirty (30) days in advance of the submission for publication. The publishing Party may be required to delay submission for publication if in the other Party's opinion such delay is necessary in order for that other Party to modify the planned submission in order to protect Confidential Information. A delay imposed on submission for publication as a result of a requirement made by the other Party shall not last longer than is absolutely necessary; and therefore shall not exceed three (3) months from the date of receipt of the material by such Party, although the publishing Party will not unreasonably refuse a request from the other Party for additional delay in the event that property rights would otherwise be lost. Notification of the requirement for delay in submission for publication must be received by the publishing Party within thirty (30) days after the receipt of the material by the other Party, failing which the publishing Party shall be free to assume that the other Party has no objection to the proposed publication.
- 4.7 Publications will carry the following disclaimer "This report is independent research supported by the National Institute for Health Research (**NIHR Career Development Fellowship, Dr Antoniya Georgieva, CDF-2016-09-004**). The views expressed in this publication are those of the author(s) and not necessarily those of the NHS, the National Institute for Health Research or the Department of Health"
- 4.8 It is the intention of the Parties that any publication of the results obtained during the course of the Project, including but not limited to the Allocated Work, shall be published jointly by the Parties. For the avoidance of doubt, this intention shall not prohibit the right of either Party to publish such results individually, provided that the procedure set out in Clause 4.6 above has been adhered to and provided that the joint publication has already been published.
- 4.9 The Parties shall comply with recognised standards concerning publication and authorship, including the *Uniform Requirements for Manuscripts Submitted to Biomedical Journals* issued by the International Committee of Medical Journal Editors.
- 4.10 Portsmouth will acknowledge the source of the Data in any publication reporting on its use.
- 4.11 The provisions of Clause 4.1 and 4.2 shall survive for a period of three (3) years from the date of termination or expiry of this Agreement. The provisions of Clause 4.6 shall survive for a period of one year from the date of termination or expiry of this Agreement.

5. INTELLECTUAL PROPERTY

- 5.1 All Background Intellectual Property used in connection with the Project shall remain the property of the Party introducing the same. Neither Party will make any representation or do any act which may be taken to indicate that it has any right, title or interest in or to the ownership or use of any of the Background Intellectual Property of the other Party except under the terms of this Agreement. Each Party acknowledges and confirms that nothing contained in this Agreement shall give it any right, title or interest in or to the or Background Intellectual Property of the other Party save as granted by this Agreement. The Parties agree that any improvements or modifications to a Party's Background Intellectual Property arising from the Project which are not severable from that Background Intellectual Property will be deemed to form part of that Party's Background Intellectual Property.
- 5.2 Each Party grants to the other a royalty-free, non-exclusive licence for the duration of the Project to use its Background Intellectual Property for the purposes of carrying out the Project but for no other purpose. No Party may grant any sub-licence over or in respect of the other's Background Intellectual Property.
- 5.3 Each Party shall own the Arising Intellectual Property generated by its employees, students and/or agents under the Project and shall ensure that it secures ownership of such Arising Intellectual Property from its employees, students and agents. Subject to the terms of the Contract, the Party owning any Arising Intellectual Property shall be entitled to use and exploit such Arising Intellectual Property as that Party sees fit, and subject always to Clauses 5.5 and 5.6.
- 5.4 Each Party shall promptly disclose to the other(s) all Arising Intellectual Property generated by it and each Party shall co-operate, where required, in relation to the preparation and prosecution of patent applications and any other applications relating to Arising Intellectual Property.
- 5.5 Where any Arising Intellectual Property is created or generated by two or more Parties jointly and it is impossible to segregate each Party's intellectual contribution to the creation of the Arising Intellectual Property, the Arising Intellectual Property will be jointly owned by those Parties in equal shares. The owners may take such steps as they may decide from time to time, to register and maintain any protection for that Arising Intellectual Property, including filing and prosecuting patent applications for any Arising Intellectual Property, and taking any action in respect of any alleged or actual infringement of that Arising Intellectual Property. If one or more of the owners does not wish to take any such step or action, the other owner(s) may do so at their expense, and the owner not wishing to take such steps or action will provide, at the expense of the owner making the request, any assistance that is reasonably requested of it.
- 5.6 Any joint owner of any of the Arising Intellectual Property may commercially exploit the Arising Intellectual Property upon consultation and agreement with the other Party/Parties. In such circumstances, the Party which is commercially exploiting the Arising Intellectual Property will pay the other Party/Parties a fair and reasonable royalty rate/revenue on the value of any products or processes commercially

exploited by it which incorporate any Arising Intellectual Property taking into consideration the respective financial and technical contributions of the Parties to the development of the Arising Intellectual Property, the expenses incurred in securing intellectual property protection thereof and the costs of its commercial exploitation and the proportionate value of the Arising Intellectual Property in any such product or process

- 5.7 Each Party is hereby granted an irrevocable, non-transferable, royalty-free right to use all Arising Intellectual Property generated in the course of the Project for academic and research purposes, including research involving projects funded by third parties provided that those parties gain or claim no rights to such Arising Intellectual Property
- 5.8 If any Party (the "Exercising Party") requires the use of Background Intellectual Property of any other (the "Other Party") in order to exercise its rights in Arising Intellectual Property (whether solely or jointly owned) then, provided the Other Party is free to license the Background Intellectual Property in question, the Other Party will not unreasonably refuse to grant or delay granting a licence to the Exercising Party so that the Exercising Party may use such Background Intellectual Property for the purpose of exercising its rights in Arising Intellectual Property

6. ASSIGNMENT

Neither Party will assign this Agreement without the prior written consent of the other Party, such consent not to be unreasonably withheld, denied or delayed.

7. TERM AND TERMINATION

- 7.1 This Agreement shall take effect on the Effective Date and (unless it is otherwise terminated in accordance with the terms of this Agreement or it is otherwise lawfully terminated) shall expire on the completion of the Project (the "Term"). The Parties may, by mutual written agreement, extend the Term in accordance with Clause 11.4.
- 7.2 Either Party may terminate this Agreement with immediate effect by giving thirty (30) days' written notice to the other Party.
- 7.3 Upon completion of the Project or earlier termination under Clause 7.2, Portsmouth will discontinue all use of the Data, and upon Oxford's direction, return or destroy the Data, unless permission to retain the Data is specifically provided in writing by Oxford to Portsmouth.

8. LIMITATION OF LIABILITY

- 8.1 Neither Party makes any representation or warranty that advice or information given by any of its employees, students, agents or appointees who work on the Project, or the content or use of any materials, works or information provided in connection with the Project, will not constitute or result in infringement of third-party rights.

- 8.2 Neither Party accepts any responsibility for any use which may be made of any work carried out under or pursuant to this Agreement, or of the results of the Project, nor for any reliance which may be placed on such work or results, nor for advice or information given in connection with them.
- 8.3 The Parties undertake to make no claim in connection with this Agreement or its subject matter against any employees, students, agents or appointees of the other Party (apart from claims based on fraud or wilful misconduct). This undertaking is intended to give protection to individuals: it does not prejudice any right which either Party might have to claim against the other Party. The benefit conferred by this provision is intended to be enforceable by the persons referred to in it.
- 8.4 The liability of either Party for any breach of this Agreement, or arising in any other way out of the subject-matter of this Agreement, will not extend to loss of business or profit, or to any indirect or consequential damages or losses.
- 8.5 In any event, the maximum liability of the Parties towards each other under or otherwise in connection with this Collaboration Agreement or its subject matter shall not exceed the sum of £50,000
- 8.6 Nothing in this Agreement limits or excludes a Party's liability for:
- 8.6.1 death or personal injury resulting from its negligence;
 - 8.6.2 any fraud or fraudulent misrepresentation; or
 - 8.6.3 any sort of other liability which, by law, cannot be limited or excluded.
- 8.7 If any sub-clause of this Clause 8 is held to be invalid or unenforceable under any applicable statute or rule of law then it shall be deemed to be omitted, and if as a result either Party becomes liable for loss or damage which would otherwise have been excluded then such liability shall be subject to the remaining sub-clauses of this Clause 8.

9. NOTICES

- 9.1 Oxford's representative for the purpose of receiving reports and other notices shall until further notice be:

Director of Research Services
University Offices
Wellington Square
Oxford
OX1 2JD
United Kingdom

with a copy to:

Departmental Administrator

Nuffield Department of Obstetrics and Gynaecology NDOG
Level3, Women's Centre
John Radcliffe Hospital
Headley Way
Headington
Oxford
OX3 9DU
United Kingdom
e-mail: grants@obs-gyn.ox.ac.uk

(using in each case the following Oxford reference: **R48585/CN001**).

- 9.2 Portsmouth's representative for the purpose of notices concerning this Agreement shall until further notice be:

Emma Woollard, Director of Finance
University House, Winston Churchill Avenue
Portsmouth P01 2UP
Email: research.finance@port.ac.uk

Any notices concerning the Project:

Dr Ivan Jordanov, Reader, School of Computing

10. FORCE MAJEURE

A Party shall not be liable for failure to perform its obligations under this Agreement, nor be liable to any claim for compensation or damage, nor be deemed to be in breach of this Agreement, if such failure arises from an occurrence or circumstances beyond the reasonable control of that Party (excluding an obligation to make payment).

11. GENERAL

- 11.1 Nothing in this Agreement shall create, imply or evidence any partnership or joint venture between the Parties or the relationship between them of principal and agent.
- 11.2 Except as otherwise expressly provided for herein, the Parties confirm that nothing in this Agreement shall confer or purport to confer on any third party any benefit or any right to enforce any term of this Agreement for the purposes of the Contracts (Rights of Third Parties) Act 1999.
- 11.3 Neither Party shall use the name or any trademark or logo of the other or the name of any of its staff or students in any press release or product advertising, or for any other commercial purpose, without the prior written consent of the other Party.
- 11.4 This Agreement and its Schedules (which are incorporated into and made a part of this Agreement) constitute the entire agreement between the Parties for the Project and no statements or representations made by either Party have been relied upon by

the other in entering into this Agreement. Any variation shall be in writing and signed by authorised signatories for both Parties.

- 11.5 This Agreement shall be governed by English Law and the English Courts shall have exclusive jurisdiction to deal with any dispute which may arise out of or in connection with this Agreement.
- 11.6 If any dispute arises out of this Agreement the Parties will first attempt to resolve the matter informally through their designated senior representatives, who are not otherwise involved with the Project. If the Parties are not able to resolve the dispute informally within a reasonable time not exceeding two (2) months from the date the informal process is requested by notice in writing they will attempt to settle it by mediation in accordance with the Centre for Effective Dispute Resolution (CEDR) Model Mediation Procedure. No party may commence any court proceedings in relation to any dispute arising out of this Agreement until it has attempted to settle the dispute by mediation and either the mediation has terminated or the other Party has failed to participate in the mediation, provided that the right to issue proceedings is not prejudiced by a delay.
- 11.7 If any one or more clauses or sub-clauses of this Agreement would result in this Agreement being prohibited pursuant to any applicable competition law then it or they shall be deemed to be omitted. The Parties shall uphold the remainder of this Agreement, and shall negotiate an amendment which, as far as legally feasible, maintains the economic balance between the Parties.
- 11.8 This Agreement may be executed in any number of counterparts, each of which when executed (and delivered) will constitute an original of this Agreement, but all counterparts will together constitute the same agreement. No counterpart will be effective until each party has executed at least one counterpart.

IN WITNESS of this Agreement, the Parties have executed this Agreement through their duly authorised representatives.

SIGNED for and on behalf of **THE**)
CHANCELLOR MASTERS AND)
SCHOLARS OF THE UNIVERSITY OF)
OXFORD)

G.M. Rowe

Name: Gill Rowe
Head, Research Services, Medical Sciences
University of Oxford
Position:

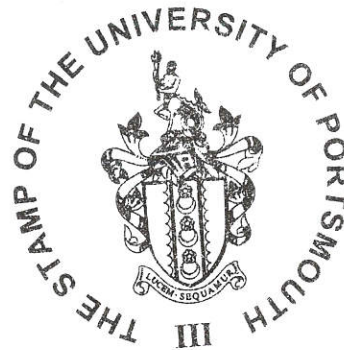
Date: 16 FEBRUARY 2017 .

Elizabeth A. Bartle

SIGNED for and on behalf of **UNIVERSITY**)
OF PORTSMOUTH HIGHER EDUCATION)
CORPORATION)

Name: Dr. Elizabeth A. Bartle
Deputy Director of Finance
Position:

Date: 24/2/17



SCHEDULE 1 – The Project

Title

Deep Learning for Foetal Monitoring in Labour.

Principal Investigators

Dr Antoniya Georgieva, Oxford Centre for Fetal Monitoring Technologies, Nuffield Department of Obstetrics and Gynaecology, University of Oxford

Dr Ivan Jordanov, Reader, and Mr Alessio Petrozziello, PhD student, School of Computing, University of Portsmouth

Background

Oxygen reaches the baby in the womb from the mother via the placenta and umbilical cord. During labour, the contractions squeeze the placenta and cord reducing the supply of oxygen to the baby. Most healthy babies cope well, but a small percentage are at risk of suffocation and brain injury. This causes each year in the UK about 100 healthy babies to die and about 1,100 to sustain brain injury during labour at term.

A baby which is at higher risk can be delivered urgently by emergency Caesarean section or instrumental vaginal extraction. To continuously monitor the baby during labour, midwives and doctors use the cardiotocogram (CTG), which continuously displays the womb's contractions and the baby's heart rate. But our understanding of how to read the CTG is limited and the patterns are difficult to interpret by eye, so some babies end up injured while at the same time many unnecessary emergency Caesareans and instrumental extractions are performed. Widely adopted in the 1970s, CTG monitoring has barely improved since. Also, because of the uncertainty with CTG interpretation, it is contra-indicated in the UK for low-risk labours, even though deciding who is at low-risk is in itself problematic. As a result, sometimes babies who would benefit from CTG monitoring do not have it. Nearly 50% of the NHS litigation bill relates to maternity claims (between the years 2000 to 2010 these amounted to £3.1bn) and the majority of these related to shortcomings in labour management and CTG interpretation.

With current computing power, it is finally possible to improve CTG interpretation by studying the relation of the CTG patterns during labour to the baby's health at birth. Dr Georgieva has already completed substantial preliminary work using routinely collected data from nearly 60,000 labours (all monitored babies in Oxford between 1993 and 2011). This 'big' database is very large which is crucial if we want to draw meaningful conclusions, especially because foetal problems are rare.

At the same time, substantial advances in computing have been made, i.e. the developments of methods for data classification using deep learning techniques and 'big data'.

The research will focus on investigation and development of learning machines that can automatically create feature extractors and using supervised and unsupervised training approaches can solve classification problems. The stress will be especially on deep learning approaches (DLA), which recent advancements [1] provide evidence that on large and big datasets, sophisticated algorithms can achieve better performance than simple models

(shallow learning traditional methods). This is due to the DLA ability to learn feature hierarchies with multiple levels of abstraction, that allow the system to learn complex functions, mapping the input to the output directly from raw data, without depending completely on man-crafted features and high level concepts, in tasks as image and signal processing [2], [3].

Deep learning approaches will be used to analyse the Database. We anticipate the developments of advanced Deep Learning architectures to classify the last hour of the CTG into one of the four outcome groups.

Allocated Work

- Oxford will provide Data for this project which include: N = 59,279 term deliveries (April 1993–December 2011), including a digital CTG for each labour and information about labour outcome. The use of this data for development of computerised foetal monitoring in labour has been approved by the Newcastle & North Tyneside 1 Research Ethics Committee, REC reference 11/NE/0044 (data before 2008) and the South Central Ethics Committee, REC reference 13/SC/0153 (data beyond year 2008). Informed consent was not required
- Portsmouth will review the datasets and develop data analytics and machine learning methods that include data pre-processing, design, implementation, testing and validation of deep learning approaches for solving foetal monitoring in labour problems. This will incorporate designing convolutional neural network (CNNs) architectures for labour outcome classification with probability distribution of the four categories.

The Parties will disseminate findings to clinical, non-clinical, wider community audiences and to all stakeholders and publish the findings in a peer reviewed international scientific journal (the investigators already have previous joint publications [4]).

SCHEDULE 2 – The Data

Details of the data

N = 59,279 term deliveries (April 1993–December 2011), including a digital CTG for each labour and information about labour outcome.

Excluded are infants <36 weeks gestation, and those with breech presentation, congenital abnormalities or metabolic disorders. Four exclusive perinatal outcome groups are considered: (1) **Severe compromise** (a composite outcome of stillbirth, neonatal death (<28 days), neonatal encephalopathy (NE), seizures; and intubation or cardiac massage at birth followed by admission to the Neonatal Intensive Care Unit (NICU) for ≥ 48 hours); (2) **Moderate compromise** (umbilical cord arterial pH at birth < 7.05); **Mild compromise** ($7.05 \leq \text{pH} < 7.15$); and **Normal** (all remaining births).

Reference List

- [1] Y. Bengio, A. Courville, and P. Vincent, Representation learning: A review and new perspectives, *IEEE Trans. Pattern Anal. Mach. Intell.*, vol. 35, no. 8, pp. 1798–1828, 2013.
- [2] Y. Zheng, Q. Liu, E. Chen, Y. Ge, and J. L. Zhao, Exploiting multi-channels deep convolutional neural networks for multivariate time series classification, *Frontiers of Computer Science*, vol. 10, no. 1, pp. 96–112, 2016.
- [3] K. Wang, Y. Zhao, Q. Xiong, M. Fan, G. Sun, L. Ma, and T. Liu, Research on healthy anomaly detection model based on deep learning from multiple time-series physiological signals, *Scientific Programming*, vol. 2016, 2016.
- [4] I. Jordanov and A. Georgieva, Neural Network Learning with Global Heuristic Optimization, *IEEE Trans. on Neural Networks*, vol. 18 (3), pp. 937–942, 2007.

