# Project Description

## Project Details

### Project Title

Virtual Reality-based Simulation for Total Hip Replacement Training

### Project Summary

Total hip replacement is a common procedure for relieving pain and dysfunction associated with adverse conditions affecting the mobility at the hip joint [1]. According to the National Joint Registry for England, Wales, Northern Ireland and the Isle of Man, 83,000 primary hip replacement surgeries were performed in 2015 [2]. This increasing number of surgeries requires innovative ways in training more surgeons.

Virtual reality simulation-based surgical skills training has become essential in orthopaedic practice as it allows practice of procedures in a risk-free environment before they are performed in the operating theatre [4]. With the increase in technically challenging procedures, VR based training provides a safe environment to practice a particular operation which could decrease the potentially of a surgery failure. Moreover, if the guidance process is automated, the training will require less supervision from experts during the training [8].

Compared to other orthopaedic surgery procedures, hip replacement surgery simulation is lagging behind as there are very few training simulators available for hip replacement and resurfacing, yet more advanced virtual reality is being used for other procedures such as hip trauma and drilling [3]. This PhD project aims to fill this gap and develop a novel virtual reality hip replacement simulator for surgeon's training and surgical practice.

During THR surgery, an incorrect acetabular positioning would result in a dislocation and/or impingement between the neck of the femoral implant and the rim of the acetabular component causing advanced wear of the acetabular rim [3]. Actually the rate of the rate of dislocation of primary hip replacements ranges from 0.2% to 10% per year, while that of artificial hip joints that have already been surgically revised can be as high as 28% [6]. The revision of such surgeries is a source of patients' dissatisfaction in addition to associated high cost and litigation.

The proposed VR training simulator could enable to train and practice of total hip replacement as many times as needed which will consequently reduce the risk of patients requiring revision surgery. This project will combine photorealistic modelling and visualisation with physically realistic simulation of anatomical structure interactions to produce a better THR simulator. This project will produce a 3D hip model with detailed and accurate anatomical structures from computerised tomography (CT) and magnetic resonance imaging (MRI) scans. The rendering of anatomical structures will be photorealistic with texture learnt from images of real hip surgery. This is an important point as the user should be able to visualize the complex anatomic structure as close to the real world as possible. To achieve this photo-realistic visualisation, machine learning will be used to predict the realistic appearance of different tissue during the surgery procedure.

During the simulation, the user will be able to:

- Navigate visually through the anatomical structures of the hip.
- Get hold of different virtual surgical tools to operate on the virtual hip.
- Cut through different tissues and bones and manipulate anatomical structures, while getting real-time accurate 3D view of the whole operation.

During the virtual operation, the simulator should able to predict the motion of the manipulated (cut, moved) tissues as well and the corresponding colour and texture. During the simulated surgery the user will always be presented
with photo-realistically rendered visualization of the complex anatomic structures of the hip. Moreover, the guidance process will be automated so as to require less supervision from experts during the training/practice.

Haptic/tactile feedback would improve the whole experience, but it will not be investigated in this project and can be explored in a future R&D project as KTP proposal.


Academic Impact

The PhD research project brings together the Orthopaedic Research Institute and the National Centre for Computer Animation to work a timely and innovative research project dealing with an important research question which is the virtual reality-based total hip replacement simulation. There are at least four types of academic impact that will be achieved:

1) Scientific output – The project is scientifically challenging thus results are expected to be published in high-impact journals;

2) Prototype simulator – The project will deliver a fully functional Virtual Reality based total hip replacement surgery simulator in the form of a proof-of-concept.

3) Internal cooperation – The project involves 2 research entities at BU: the Orthopaedic Research Institute and the National Centre for Computer Animation and this is a great opportunity to exploit the wealth of expertise in both.

4) Networking – the student will staff from both the Orthopaedic Research Institute and the National Centre for Computer Animation and will have many opportunities to interact with existing industrial partners of both the institute and the centre.

Societal Impact

According to [1], in the UK there are over 12 million people aged over 65 and by 2030, their number will be nearly 1/4 of the population. Hence the number of people who are likely to need a total hip replacement surgery will increase. Already in 2015, over 83,000 primary hip replacement surgeries were performed in England, Wales, Northern Ireland and the Isle of Man. This increasing number of surgeries requires innovative ways to train more surgeons and give existing surgeons the opportunity to practice surgeries before operating on patients. The proposed simulator will provide a training/practice platform and will definitely help in reducing the rate of both the dislocation of primary hip replacements which ranges from 0.2% to 10% per year, and that of already surgically revised surgery which can be as high as 28%. This training/practice platform will improve the outcome of the hip replacement surgeries and subsequently patients’ satisfaction in addition to reducing cost.

Training Opportunities

This project offers a very interesting learning and training opportunity for the candidate. In fact this project is interdisciplinary by nature as it brings together orthopaedic surgery and computer science together to build a virtual reality-based simulator for total hip surgery. Hence the candidate will have the opportunity to interact with local and national researchers in both disciplines and will be expected to attend international conferences and present his finding to mixed audience. At the Orthopaedic Research Institute, the candidate will have access to some existing simulators such as knee simulator. The access to such simulators will give the candidate a head start in his understanding of the requirements for orthopaedic simulators. Moreover, at the National Centre for Computer Animation, the student will have access to different modelling, animation and visualisations courses.

SUPERVISORY TEAM

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<tr>
<th>First Supervisor</th>
<th>Dr Hammadi Nait Charif</th>
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<tr>
<td>Additional Supervisors</td>
<td>Dr Xiaosong Yan</td>
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<td>Dr Tom Wainwright</td>
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<td>Prof Rob Middleton</td>
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Recent publications by supervisors relevant to this project

INFORMAL ENQUIRIES

To discuss this opportunity further, please contact Dr Hammadi Nait Charif via email: hncharif@bournemouth.ac.uk

ELIGIBILITY CRITERIA

Studentship candidates must demonstrate outstanding academic potential with preferably a 1st class honours degree and/or a Master's degree with distinction or equivalent Grade Point Average. An IELTS (Academic) score of 6.5 minimum (with a minimum 5.5 in each component) is essential for candidates for whom English is not their first language. In addition to satisfying basic entry criteria, BU will look closely at the qualities, skills and background of each candidate and what they can bring to their chosen research project in order to ensure successful completion.

Additional Eligibility

A good knowledge of an object oriented programming language as much of the development work will include C++. A good computer graphics background is desirable.

HOW TO APPLY

Please complete the online application form by 23/04/2017. Further information on the application process can be found at: www.bournemouth.ac.uk/studentships