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ANALYZING THE IMPACT OF A NEW TECHNOLOGY WITH SIMULATION OPTIMIZATION: USING PORTABLE ULTRASOUND SYSTEM AS AN EXAMPLE

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ABSTRACT

New technologies challenge current approaches in most industries, but decisions concerning their adoption often involve evaluation of complex trade-offs and consideration of a large number of alternative choices. This poster considers portable ultrasound machines as an example of a new technology that might be sued to replace or supplement magnetic resonance imaging (MRI) for shoulder disorder diagnosis in orthopedic clinics. When implementing portable ultrasound machines, patient health outcomes need to be considered in addition to costs. A discrete-event simulation model and a simulation optimization algorithm are used to analyze the trade-off between health outcomes and the cost of implementing the portable ultrasound machines. The decisions include purchasing and locating portable ultrasound machines, training of users at appropriate clinics and the MRI capacity allocated for shoulder disorders. The simulation optimization algorithm provides an approximated Pareto optimal set of system designs that allows decision makers to comprehensively understand the trade-offs.

EXTENDED ABSTRACT

New technologies appear in different industries and compete with current existing approaches. The introduction of portable ultrasound machines to orthopedic clinics is a specific example of a new technology. This poster considers shoulder disorder patients, which may require an imaging support to be diagnosed. The current major approach to image shoulder disorder patients is magnetic resonance imaging (MRI), however, newly developed portable ultrasound machines are considered as an alternative. The advantages of using a portable ultrasound machine are the low cost and the capability to be used by a trained physician or surgeon at the orthopedic clinic (Adelman and Fishman 2013). It provides point-of-care convenience for patients, and may reduce or eliminate the waiting and traveling to the radiology for MRI (Moore and Copel 2011). Also, the immediate imaging and diagnosis allows the patient to schedule a surgery, if needed, or start other treatment earlier than the traditional diagnosing procedure with MRI imaging (Seagger et al. 2011). The ultrasound provides imaging for diagnosis with no significant quality difference (Teefey et al. 2004, Vlychou et al. 2009). However, the equal imaging quality is based on specialists with ten years of experience. The newly trained physicians and surgeons could have a higher probability of an incorrectly diagnosis. Therefore, the trade-offs are analyzed with a discrete event simulation model and a simulation optimization algorithm to identify a set of system designs.

The hospital system considered includes multiple orthopedic clinics and regional central radiology departments. If a patient requires imaging by MRI, the patient will be scheduled to the closest radiology department at the first available time, considering the capacity of MRI that can be used for shoulder disorders. When a portable ultrasound machine is allocated to an orthopedic clinic, patients may be immediately diagnosed with the imaging by the portable ultrasound machine. Once a patient is diagnosed, the patient could require a surgery or other treatments. Decisions need to be made at each clinic about purchasing of

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a portable ultrasound machine and the associated training. Also, the corresponding capacity of MRI to be used for shoulder disorders at the regional radiology department need to be determined.

Most of the simulation optimization algorithms focus on approximating the optimal design with a single performance metric (Fu 2002, Fu et al. 2005, Tekin and Sabuncuoglu 2004). However, in practice, it is common to have multiple objectives, such as the cost and health outcomes in the portable ultrasound machine problem. To investigate the trade-offs between objectives, approximating the Pareto optimal set is a direct approach to provide information to the decision makers. With a small set of alternatives, ranking and selection algorithms allocate computational resources for identifying the Pareto optimal designs with rigorous statistical quality (Lee et al. 2004, Lee et al. 2010). When it is impractical to evaluate all alternatives, meta-heuristic algorithms are considered as an effective method (Lin, Sir, and Pasupathy 2013). Huang and Zabinsky (2014) proposed a partition-based algorithm, Multiple Objectives Probabilistic Branch and Bound (MOPBnB), to approximate the set of Pareto optimal designs with statistical quality provided. This poster uses MOPBnB to approximate the Pareto optimal designs of the portable ultrasound machine allocation problems and provide the trade-off information for the decision makers.

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