Bayesian Qubit Tomography

A. Magyar[1], **K. M. Hangos**[1], **D. Petz**[2]

[1] Process Control Research Group, Computer and Automation Research Institute HAS, Budapest, Hungary
[2] Rényi Institute for Mathematics HAS, Budapest, Hungary

E-mail: amagyar@scl.sztaki.hu

Keywords: Bayesian estimation, quantum systems, qubit tomography

Abstract: Quantum mechanics is one of the most interesting field in modern physics. In spite of its great importance related to quantum computers and quantum information theory, just a few person has tried to use the tools of control theory for quantum systems.

In quantum mechanics the nature of measuring is very different from measuring in classical physics, because it represents not only the measuring itself but also an intervention to the system. After a measurement, the system's state jumps to an eigenstate determined by the result of the measurement. Using a quantum computing example: one cannot get any partial result of a computation, otherwise it will be lost and one cannot finish the computation. Among others it makes quantum systems difficult to deal with.

Technically, the state of the system cannot be determined from just one measurement, so multiple copies of the system is needed being in the same quantum state. The above properties of quantum systems call for a nonlinear stochastic system model as their representation.

The simplest system in quantum mechanics is a so called *spin* $1/2$ *particle* which represents a quantum bit, or a *qubit*. The state of this system can be represented by a 3-dimensional real vector with length less than or equal to 1. The state space of this system is a unit sphere, which is called *Bloch sphere*. A procedure that determines the value of the Bloch-vector pointing to a point in Bloch sphere is called *qubit tomography* [1].

In this work we are trying to give a Bayesian estimation of the state of a single qubit by using six static measurements. The proposed method gives independent estimations for each of the 3 components of the Bloch-vector. It is shown that the estimate of each component is a random variable with binomial distribution.

References

[1] D. K. J.Řehaček, B-G. Englert, "Minimal qubit tomography," *arXiv:quant-ph*, Nov. 2004.