Best Conventional Solutions to the King's Problem

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In the King's Problem, a physicist is asked to prepare a d-state quantum system in any state of her choosing and give it to a king who measures one of $(d+1)$ sets of mutually unbiased observables on it. The physicist is then allowed to make a control measurement on the system, following which the king reveals which set of observables he measured and challenges the physicist to predict correctly all the eigenvalues he found. This paper obtains an upper bound on the physicist's probability of success at this task if she is allowed to make measurements only on the system itself (the "conventional" solution) and not on the system as well as any ancillary systems it may have been coupled to in the preparation phase, as in the perfect solutions proposed recently. An optimal conventional solution, with a success probability of 0.7, is constructed in $d = 4$; this is to be contrasted with the success probability of 0.902 for the optimal conventional solution in $d = 2$. The gap between the best conventional solution and the perfect solution grows quite rapidly with increasing d.

Key words: Quantum State Retrodiction; Quantum Algorithms.