

Set-valued KKL observer design for non observable systems

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We present the theory of KKL observer design, which consists in finding a smooth change of coordinates transforming the system dynamics into a linear filter of the output. Its interest is that the state of the original system can then be reconstructed by implementing this filter from any initial condition and left-inverting the transformation, if the system is backward-distinguishable. But we show that this theory is still relevant when the latter assumption does not hold, namely when distinct solutions may generate the same output, and thus be indistinguishable : the system state could then be reconstructed modulo its indistinguishable class. More precisely, the KKL transformation is no longer injective and its “left-inverse” is allowed to be set-valued, yielding a set-valued KKL observer. Assuming the transformation is full-rank and its preimage has constant cardinality, we show the existence of a globally defined set-valued left-inverse that is Lipschitz in the Hausdorff sense and that is linked to the backward-indistinguishable sets, so that the set-valued KKL observer converges in the Hausdorff sense to the backward-indistinguishable set of the system solution. When, additionally, a given output is generated by a specific number of solutions not converging to each other, we show that the designed observer asymptotically reconstructs each of those solutions.

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