# Safe and Optimal controller synthesis for Hybrid System

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Abstract—Hybrid systems are commonly used in engineering applications(eg. logic-dynamic controllers, internet congestion even physical systems with impact,etc). Hybrid systems have been used to model several cyber-physical systems.In This work, we propose a methodolody which provide safety and optimal behaviours to hybrid systems.

Index Terms—component, formatting, style, styling, insert

# I. INTRODUCTION

Hybrid systems are widely used in engineering applications and its importance has grown up considerably these last years, because of their ease of implementation for controlling cyberphysical systems. A switched systems is a set of dynamical systems, each with its own dynamical behaviour controlled by a parameter mode u whose values are in a finite set  $U(\text{See}\ [\color{loop}])$ . However, due to the composition of many switched systems together, the global switched systems has a number of modes and dynamics which increases exponentially. Switched systems have numerous applications in control of mechanical systems, the automotive industry, and many other fields.

#### II. SAFETY HYBRID SYSTEMS

In this part is presented a method based on correction by design of discrete linear switched system in the time. the method consist of given a objective region R of state space, the method built a set S and a control that guide any element from S a R. This method works in an iterative way to back to reach the region R. The method can also be used for synthesize a stability control that is keep inside of R, whole states start in R.

**Problem 1** ((R,S) - *Stability Problem*). Given a switched system as shown in figure before, a set of recurrence  $\mathbb{R}^n$  and a safe set S

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 $\subset \mathbb{R}^n$ , find a control rule  $\sigma: \mathbb{R}^+ \to U$  such that, for any initial condition  $x_0 \in R_1$  and any perturbation  $\varpi: \mathbb{R}^+ \to U$  the following holds:

- Recurrence in R:there are a monotonically strictly increasing sequence of (positive) integers  $k_t, t \in \mathbb{N}$  such that for all  $t \in \mathbb{R}^n$ ,  $\phi(k_l \tau; t_0, x^0, \sigma, w) \in \mathbb{R}$ .
- Stability in S: for all  $t \in \mathbb{R}^n$ ,  $\phi(t; t_0, x^0, \sigma, w) \in S$ .

**Problem 2**  $((R_1,R_2,S)$  - Reachability proglem). Given a switched system of the form shown above, two sets  $R_1 \subset \mathbb{R}^n$  and  $R_2 \subset \mathbb{R}^n$  and a safety set  $S \subset \mathbb{R}^n$ , find a control rule  $\sigma$ :  $\mathbb{R}^+ \to U$  such that, for any initial condition  $x_0 \in R_1$  and any perturbation  $\varpi : \mathbb{R}^+ \to U$ , the following holds:

- Reachability from  $R_1$  to  $R_2$ : there exists an integer  $k \in \mathbb{N}$  such that we have  $\phi(k_l \tau; t_0, x^0, \sigma, w) \in R_2$ .
- Stability in S: for all  $t \in \mathbb{R}^+, \phi(t; t_0, x^0, \sigma, w) \in S$ .

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**Problem 3**(Control Synthesis Problem). Let us consider a sampled switched system. Given three sets R,S and B, with  $R \cup B \in S$  and  $R \cap B = \emptyset$  find a rule  $\sigma(.)$  such that, for any  $x(0) \in R$ .

- $\tau$ -stability: x(t) return in R infinitely often, at some multiples of sampling time  $\tau$ .
- safety: x(t) always stays in S/B.

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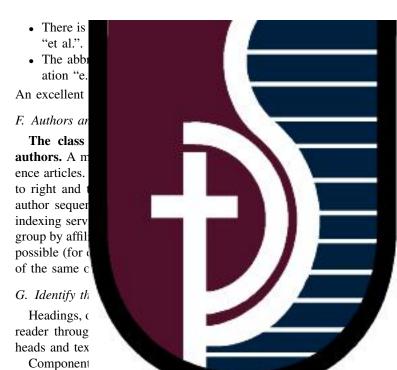
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Fig. 1. Example of a figure caption.

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#### ACKNOWLEDGMENT

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