PCA Description

PCA

Patient Controlled Analgesia is a medical device to provide real time drug delivery to patients in a controlled manner.

Code Description

The PCA is designed as a Finite State Machine.

The input from the environment is captured and used as Events in the state machine.

The events trigger the execution of the current State and if required update the current state.

Event:

Sensors attributed to the PCA providing the Events are as follows:

Sensor Events

* Keypad: Provides a rising edge on a pin associated with the key pressed

ON(p8)

OFF(p9)

BACK(p10)

ENTER(p11)

UP(p12)

DOWN(p13)

BOLUS(p14)

LOAD(p15)

* State Sensor: Provides a rising edge or a falling edge describing the presence or absence of an event:

DOORSENSOR(p5) - Rising edge if Door Closed

- Falling edge if Door Opened

SYRINGESENSOR(p6) - Rising edge if Syringe Present

- Falling edge if Syringe Absent

LEVELSENSOR(p7) - Rising edge if Syringe Level is High

- Falling edge if Syringe Level is Low

The behavior of the state machine to an event is specified in a state table expressed in Excel.

The specification described is simulated and deadlock property is verified using the model checking tool – UPPAAL.

The State machine is implemented in C.

Sate Machine Structure:

TstateMachine is an instance of the StateMachine Structure, containing the Current State and the Previous State.

Current State and Previous State are function pointers, of type StateProc(function pointer), representing the state.

Code Execution:

The occurrence of an event is defined by the sensor, setting the appropriate pin in the controller high, which executes an ISR. The ISR will call the function pointed by current State, and pass the Event description.

The execution of the function will update state parameters and update the function pointer to point to the next state corresponding to the event.

Modes Of Operation

Continuous Mode:

Introduction: In this mode drug is induced continuously in a predetermined rate, and does not allow the patient to request additional dosage.

Inputs required: concentration: c mg/ml

Continuous rate: d mg

Operation: The PCA accepts Concentration and concentration rate, and starts issuing the dosage at the defined rate. Once the defined dosage is delivered, the PCA goes to the Initial state

The rate is interrupted when the Door is Opened/ Syringe is Absent/ Level is Low.

The state of the PCA is restarted once the interrupted signal is removed

Input requirements:

1. minimum value of lockout time is 5 min

2. value of 'c' has to be from the set {c1, c2, c3.. cn}

3. value of 'd' will be limited based on value of 'c'. (d/c << V);

PCA Mode:

Introduction: In this mode drug is induced on patient requests. Patient can request for drug using bolus. Caregiver is allowed to set certain restrictions on the amount of drug to be induced on each request and also the frequency at which the patient can request.

Inputs required: concentration: c mg/ml

dosage: d mg

lockout: l min

Operation:

1. When patient presses bolus, adminster 'd' mg of drug. This can be done by operating motor for d / (c \* s) minutes

2. Once drug has been adminstered, if patient presses bolus with-in 'l' minutes, it is ignored. In other words only bolus requests spaced 'l' mins apart are considered valid.

Input requirements:

1. minimum value of lockout time is 5 min

2. value of 'c' has to be from the set {c1, c2, c3.. cn}

3. value of 'd' will be limited based on value of 'c'. (d/c << V);

PCA + Continuous Mode:

Introduction: In this mode, there is a continuous supply of the drug at a set constant rate in addition to extra dosage whenever the patient requests for it provided certain conditions are satisfied.

Inputs required: concentration: c mg/ml

continuous dosage: x mg

dosage: d mg

lockout: l min

Operation:

1. There is a constant drug infusion at x mg/hr in normal operation mode.

2. Once the patient requests extra dosage by pressing the bolus, an additional dosage of d mg/hr is delivered as fast as possible provided that the patient had not requested for an extra dose l min before this dose.

Inputs requirements:

1. minimum value of lockout time is 5min

2. value of c from a set of value {c1,c2,c3 ..cn}

3. value of x between 0 and 100 in steps of 0.1

4. value of d between 0 and 100 in steps of 0.1

Language choice

C: Ease of implementation of function pointers

Not C++: No recursive use of a function.

Patient Model