Object Position and Orientation Tracker

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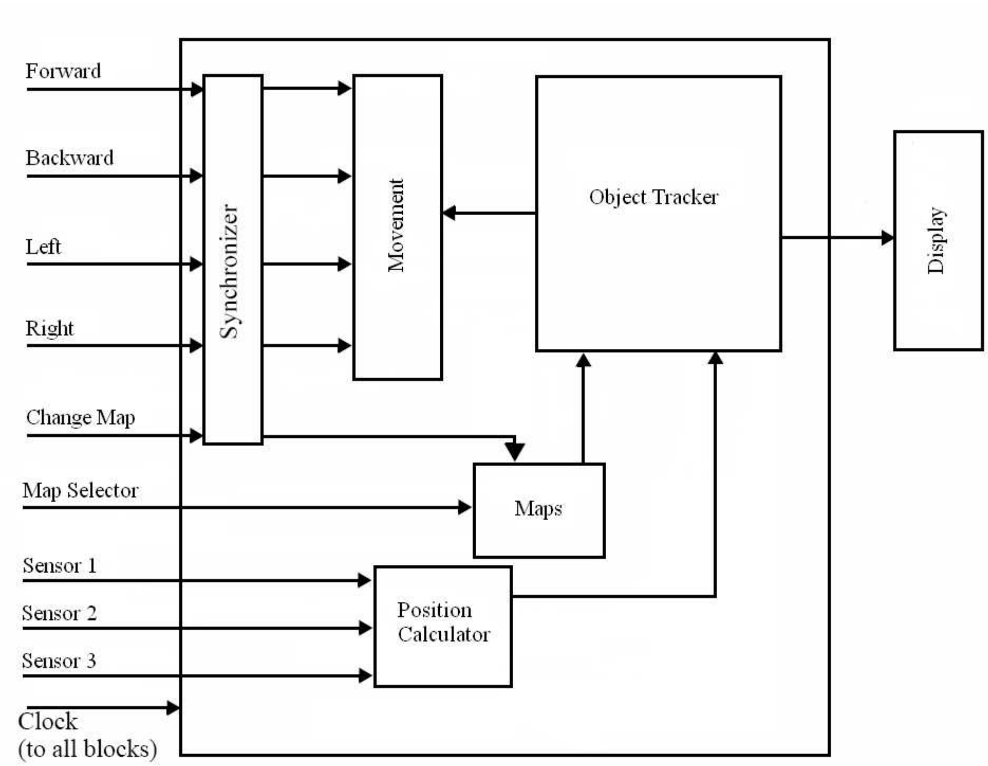
Project Description

The purpose of this project is to develop a digital tracker that can determine the exact position and orientation of an object in a predefined area. Applications of this system would involve mostly object location. For example, the tracker could be used to determine the location of a person within a room and distinguish what the person was looking at or doing based on the orientation of the body. Other applications include wall detection, such as indications of when an object is too close to a wall or barrier, or area detection, such as indications of when the object has entered a particular region in the predefined area. The position of the object will be calculated and displayed via the computer monitor.

For this project, the tracker system will be modeled using a remote controlled car placed within a box to simulate an object navigating through a room. Spread within the "room" will be three receiving sensors that will receive and record signals from two emitters placed on the front and back of the car. Besides just tracking the movement of the car as it moves within the empty space, there will be a few predefined maps for the car to traverse through. One example is a maze-like plane in which the car must avoid virtual walls to get from one point to another. Another example is a "mine field" in which the car must cross safely by avoiding certain regions in the space. Additional possible applications may include defining a virtual racecourse or allowing users to create custom maze layouts.

By analyzing the time delay between when signals are received at each receiver, the exact position of each emitter can be determined. Since the two emitters will be emitting at different frequencies, it will be possible to differentiate between the front and the back of the car and thus be able to determine its orientation. Once the locations of the emitters are determined in relation to the receivers, the position of the car can be displayed on the screen as an object in a rectangle facing a certain direction. Also by analyzing the position and orientation of the car, it will be possible to determine the distance from walls and objects within certain regions and emit notifications to the user.

Project Specification



Block Diagram of Object Tracker

The tracker system takes in numerous inputs including the system clock, signals from the receiving sensors, car controller signals, and user defined map selections.

The car controller inputs are asserted through the up, down, left, and right buttons on the FPGA labkit. Since these signals are asynchronous to the system clock, they are first run through a **synchronizer** module before being processed within the system. The user asserted inputs control the forward and backward motion of the car and the side to side turning of its wheels.

The map selectors are asserted through the switches and reset button on the FPGA labkit. Based on the values of the switches, the user will be able to select between predefined terrains such as the maze or mine field by specifying a certain parameter code. The specified terrain will not take effect until the reset (reprogram) button is pushed. The reset button is also asynchronous to the system clock and will have to be inputted into the synchronizer module. All these values are processed within the **maps** module which outputs the terrain map encoding to the object tracker module.

Input from the receiving sensors is directed to the **position calculator** module which will translate the signals into coordinate values to map the location of the car. These values are in turn outputted to the object tracker module which serves as the central computation unit of the system.

The **object tracker** module keeps track of the location of terrain elements such as walls and object, direction inputs from the controller, as well as the position of the car being tracked and performs the analysis for the system. The virtual walls and objects which are predefined, or may be customized by the user, set boundaries for the object, preventing it from taking certain paths or crossing into certain areas. These constraints are enforced by means of a feedback loop from the object tracker to the movement module. Within the object tracker module, the position of the car is matched against the position of the predefined objects as specified by the map encoding and if a conflict or collision occurs, the movement of the car in certain directions will be disabled. For example, if the car is going to collide with a wall, the FPGA will not register an asserted forward command and prevent the car from moving forward beyond the boundary.

The **movement** module governs the motion of the object being tracked. This module takes in the synchronized direction controller signals and notifies the object tracker module to update the position of the car. The module also matches the direction controller signals against the feedback signal from the object tracker module and determines whether certain movements are allowed (i.e. preventing traversal through walls or forbidden regions).

Once the position of all terrain elements and tracked object are determined, they can then be visually mapped and displayed through the VGA monitor. The motion and position of the visuals will be determined by the object coordinate values.

System Testing

Much in the same fashion as past lab projects, each individual module will be programmed and tested separate from other modules before piecing them together into the whole system.

The movement module can be tested by making sure the asserted buttons propagate the proper signals for updating the position of the car. In addition, these updates must also be prevented if inputted feedback signals block certain directional motion.

The position calculator can be tested once the sensors are set up by verifying the ascribed signals are converted correctly into a prescribed coordinate system. This can then be implemented using a actual moving car.

The maps module can be tested by first ensuring the user inputted values are being read and processed correctly and then properly outputted to the object tracker module.

The object tracker module will be tested in a series of stages. The module must hold the information for terrain element location as specified by the selected terrain and given the car position coordinates output proper signals allowing or prohibiting the car's physical and virtual movement.

Lastly, the display module will be tested by ensuring the pixels corresponding to object and car locations are mapped accurately.

Task Division

Project responsibilities will be divided based on the two major focuses of the system (motion processing and visual display) and subsequently the system modules.

Andrew Lee will be in charge of the motion processing of the system, more specifically the movement and position calculator modules. This will involve working out the algorithms by which the sensor signals will be mapped into coordinate values and the motion constraints.

Tiffany Wang will be in charge of the visual display of the system, inclusive of the maps and display modules. This encompasses mapping coordinate values into pixel displays and setting up the predefined terrain elements such as walls and mines.

The object tracker module will require a collaboration of both parts of the system and will be a shared responsibility.