Standalone Intelligent Sensor (SIS)

Concept Document

1. Product Concept.

The Standalone Intelligent Sensor (SIS) is an inexpensive system that processes information from a variety of passive wireless sensors to create a timestamped log containing meaningful information and inferences about a person's in-home activities. The SIS log can be securely accessed over the Internet, providing caregivers and concerned relatives a picture of how competently an elderly person living alone is performing the routine activities of daily life.

The initial release of SIS uses wireless proximity infrared (PIR) motion sensors and wireless door separation sensors to log movements of a person around and in/out of their home. Judicious placement of the PIR sensors provides a compact picture of a person's activities via the natural association of those activities with areas of the home; e.g. bedroom for sleeping and dressing, bathroom for personal hygiene, kitchen for food preparation and living room for relaxation and socialization.

The SIS consists of a number (up to 20) of inexpensive wireless sensors and a small hub device containing wireless receivers, an advanced microcontroller, and WiFi connectivity. The current release of SIS requires WiFi for connection to the Internet; however, a 3G wireless version is anticipated in the near future. SIS also contains client software that can communicate with the in-home hub over the Internet, via a free cloud service from *particle.io*. The client software is written in Javascript and can be hosted on any device that supports a Javascript enabled web browser (desktop, laptop, tablet, smart phone, etc.). Communication between the SIS hub, the cloud and a client is authenticated and encrypted to ensure privacy and security of the data.

SIS achieves low cost by performing all sensor data processing internally on the SIS hub's advanced 32 bit microcontroller. Cloud processing of the sensor data is not required. A free cloud service is used to connect the SIS hub and authenticated clients via the Internet. An SIS hub can be built for around $50 in parts and the sensors cost between $3 (for a door separation sensor) and $8 (for a PIR sensor). Total system cost (assuming an existing WiFi access point in the home) will be between $100 and $200, depending upon the number and types of sensors required for a particular home environment. There are no monthly recurring charges, other than an assumed existing WiFi capability.

SIS supports a variety of low cost sensors that can be obtained from many sources including over the Internet from EBay and Amazon. SIS supports both wireless sensors operating at both 315 MHz and 433.92 MHz within the one system. Sensors are available to sense:

- Door/window opening.
- Motion (via PIR).

- Vibration.
- Water level.
- Smoke/fire
- Keyfob
- Arduino software has also been developed to transmit compatible sensor trip codes so that specialized sensors may easily be developed.

SIS is released under an “open source, non-commercial” license. The software, hardware designs, parts lists, instructions and manuals are provided free of charge to non-commercial users. SIS is not a product; the user must use the information provided to construct, install, configure, and test the SIS for their specific environment.

The software for the initial release of SIS will provide a reasonable picture of the daily in-home activities of a person that lives alone. It attempts to sense when more than one person is in the home and lock out logging of activities to prevent false positives. The data processing internal to SIS does not attempt to establish and report “normal” vs. “abnormal” activities of a person in the home. Rather, SIS logs compact information about a person’s movements around the home and leaves it up to the caregiver or relative to determine if the person’s activity patterns have changed. This, coupled with low hardware cost, is what makes SIS an inexpensive solution vis-a-vis more complex and expensive systems.

SIS draws only a few inferences from sensor data; specifically:

- When a person is home or not home.
- When a person is home but not moving at all.
- When multiple people are in the home.

Because all of the SIS design information is open source, SIS firmware and client software may be modified to address other applications in the future. The SIS may be thought of a general purpose platform for interfacing low cost wireless sensors with clients over the Internet.

2. Use Cases.

The initial release of SIS provides general information about the movement of a person inside of the home. Field testing has demonstrated that a limited number of types of sensors can provide a remote client user with sufficient information to determine when and what activities of daily living the person in the home being monitored is performing. A daily review of the logged data is sufficient to detect abnormal patterns; e.g. a person is not leaving the bedroom in the morning or a person is visiting the bathroom several times during the night. More advanced (and more expensive) in-home activity monitoring systems seek to answer additional questions, some of which are posited below. It should be possible to answer these questions with SIS by integrating additional sensors and developing special firmware to make inferences from the sensor data.

2.1. Aging In Place Use Cases.

2.1.1. "I am concerned that Grandpa is not eating."

A caregiver or loved one is concerned that an elderly person is not eating regularly and needs to be moved to a facility where their dietary needs are met and monitored. The elderly person is pushing back, claiming that they are eating and are perfectly capable of living at home and of caring for themselves. A compromise position has the elderly person agreeing to SIS monitoring of their kitchen activities via proximity sensing and sensing of one or more food related activities:

- opening and closing the refrigerator door.
- running a microwave or toaster oven.
- running of the stovetop and/or oven.
- opening/closing silverware draw or flatware cabinet.
- running of the dishwasher.

The initial release of SIS logs movement into and out of the kitchen. It also supports the logging of data from separation sensors and specialized sensors; however, it does not draw inferences from these additional sensors. Being open source, SIS firmware can have additional inferences added to better support this use case.

2.1.2. "I called Mom when she should be home but the phone is not answered."

The question here, of course, is whether Mom is in the house and unable to answer the phone (due to fall, stroke, or other serious problem) or whether she is just fine and decided to go out of the house or apartment, perhaps for socialization activities. The concern could be mitigated if the state of "in the house" and "out of the house" could be known. Without relying on the person wearing a certain commercial fob with Near Field Communication capabilities, the activities of "leaving the house" and "entering the house" could be timestamped, logged and accessed via the Internet. SIS can provide such information, particularly if the person lives alone. The initial release of SIS supports this use case, and more. An enhancement, however, might be to support user configuration of normal "out of the house" times and send the user an alert if the elderly person leaves the home at an unexpected time (which might be an indication of illness or wandering).

2.1.3. "Last year Dad had a urinary tract infection but did not tell anyone about it. Ultimately, he had to be hospitalized".

There were indications of this infection, of course, but Dad ignored them. He woke up ten times that night to go to the toilet. However, he didn't think anything of this and didn't tell anyone about it. Now, family has confronted Dad with this problem, suggesting that it is an indication that he can no longer live alone at home. Dad denies this and, although prone to these infections, insists that he "knows better now" and promises to tell family the "next time". Family

members remain concerned and believe that the problem will recur, perhaps this time resulting in his death due to lack of timely treatment.

The initial release of SIS will support this use case by logging movement between the bedroom and bathroom. The initial release of SIS can also log trips of a water level sensor that is mounted inside the toilet tank that positively indicates when the toilet is flushed.

2.1.4. "I am concerned that Mom is staying in bed all day with the lights off and the drapes drawn. She denies the depression."

The initial release of SIS will log movement into and out of the bedroom. Review of the log can determine if Mom is not getting out of bed (at all, or not when expected). Additional sensors and algorithms may be developed to add important information; e.g. is Mom in bed or moving about the bedroom? Is the bedroom lit or dark? Is the TV on or off? Etc. It may be possible to develop algorithms for SIS that use this additional sensor information to sense that Mom is having symptoms of depression and to send an alert to the caregiver or relative accordingly.

2.1.5. "Beloved Aunt Millie has emphysema and is not allowed to smoke. She lives alone and her loved ones are concerned that she continues to smoke and is likely to die if her smoking is not monitored."

SIS can be fitted with a smoke detector sensor and will log instances of smoke detection along with movement around the house. An enhancement would be to proactively alert a family member if the sensor is triggered.

2.1.6. Uncle John has left the freezer door open several times. The food has spoiled and then refrozen. This is a health danger.

An SIS-compatible temperature sensor may be developed to detect, log and alert a remote user in the event that the temperature inside the refrigerator gets too high, indicating that the food may spoil if the situation is not corrected promptly.

2.2. Home Monitoring Use Cases.

2.2.1. "I am getting forgetful and prone to leave the water running in the sink."

SIS could use a compatible water level sensor to log instances of the sink filling up. A firmware enhancement to SIS could send an alert to a caregiver or family member in this event. A hardware and firmware enhancement could shut off the water supply before folding occurs, and or set off an audible alarm to the resident. An SIS compatible sensor could be developed to sense water flow. This sensor could be used, in conjunction with SIS's current capability to

determine where a person is in the home, to log instances where the water is running but the person has left the kitchen or bathroom. A firmware enhancement to SIS could send an alert to a family member or caregiver, in addition to logging these instances of forgetfulness.

2.2.2. "Rainwater collects under my house. I have an automatic sump pump to pump the water out, but the pump sometimes fails and I am concerned about the foundation being flooded in a rainstorm."

An SIS compatible water level sensor and/or a moisture sensor could be used to determine if water is building up under the house. If it is, then the sump pump is not operating properly and the user can be alerted through the SIS Hub.

2.3. Other Use Cases.

2.3.1. "I have a greenhouse in which I grow valuable plants. I need to know when the temperature or humidity gets out of a predetermined range so that I can intervene to save the plants from dying."

Assuming that the greenhouse has AC power or is within 100 feet of a location where the SIS Hub can be installed, an SIS can be fitted with a temperature/humidity sensor and be programmed to log temperature and humidity and to alert the user whenever either measurement goes out of prespecified limits.

3. SIS Technical Description.

A complete technical description of SIS can be found in the "SIS Theory of Operation and Installation Manual", which can be found at:

https://github.com/TeamPracticalProjects/SISProject/blob/master/SISDocs/SIS_Theory_of_Operation_and_Installation.pdf