Project Current / Prosjekt Strøm

Remote Sensing of River Levels using L-O-R-A for Predictive Flood Management

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PROJECT SUMMARY

Project Current is a collaborative student led project with local industry [1] and Kristiansand International School. The project uses relatively low cost battery driven pressure sensors, and continuously collects data from a local stream in Kvinesdal, where the data is sent wirelessly using Long Range Radio Signals (LORA) to a server. In collaboration with Intoto AS, based at Coverks in Kvinesdal, data on the server is processed continuously and presented.

The project's goal is short term, and long term. The goal is to predict floods in the sensor placement area after long term data collection is imputed into a machine learning algorithm. The placement of a sensor in the Heldsals stream (Heldalsbekken) in December, 2021 is a demonstration pilot project collecting data on stream water levels, showing practically in the short term how such data can be acquired, interpreted, and shared. The long term goal is to demonstrate how *students* can in a practical way collaborate with industry in our local communities and use such cost effective and innovative technologies to highlight these natural resources and discover new and cost effective ways to collect the data.

PROJECT RELEVANCE

Floods are one of the most destructive natural disasters, they damage everything including lives, infrastructure, agriculture and social and economic systems. Machine learning in recent years has contributed enormously to water level forecasting in both short term and long term flood prediction (Mosavi et al.) This project demonstrates how such technology can assist communities in predicting flooding events through machine learning with consistently updated data from streams and rivers based on water level trends and rising levels further upstream in rivers. As our project is based in Kvinesdal this is profoundly important due to the previous floods of the Kvina River. These floods without warning can damage businesses, schools, and peoples homes. The most recent flood happened in 2015 due to storm Synne. This flood closed roads and railways as well as evacuating many people from their homes. (The Local Norway) Sensors such as the ones developed by local industry, and in particular the open source pressure sensor we have used,

[1] Powafa and Intoto are two of Agder's innovative companies in acquiring live river data.

measure water level trends over a lengthy period of time to predict yearly and monthly water levels based on rainfall both upstream and in the place of the sensor. As the sensor updates every five minutes, it can predict flash floods within the space of five minutes. Municipalities, residents, and the media and those affected have access to real-time information with high accuracy about what is happening. The combination of local data and open historical data enables several solutions to predictions. This project is not only relevant within our experimental region, it can also be used around the world. The use of this sensor globally could help to develop machine learning algorithms that function to warn of floods and help communities. This could also be used to show global warming progression through sea level changes in coastal societies at risk.

Using students as grass-roots activists in engaging with technology can inspire other students to engage locally to come up with solutions for the problems caused by climate change and river flooding. The future development of this project involves collaboration with schools in their local communities, serving as a pilot project where students from other schools can duplicate the open source technology, connect with local industry, identify streams and rivers of interest, and go out into the field and place the sensors. More sensors could be placed further upstream to warn those downstream of rising water levels with adequate time to evacuate the downstream area.

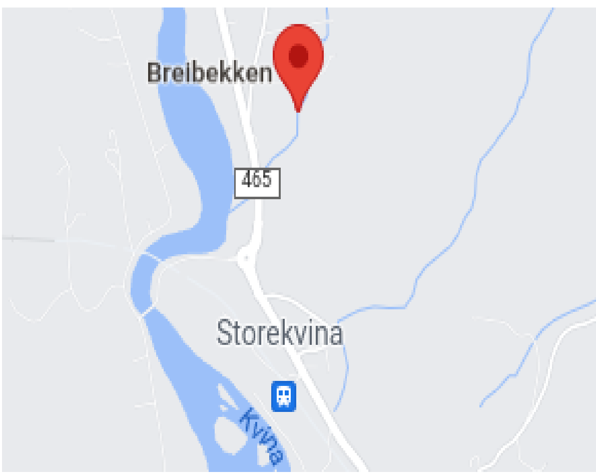
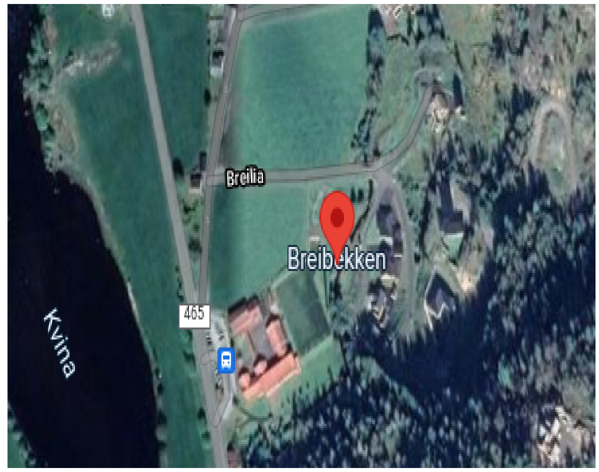
The culvert under the road is full and a further increase in water flow would have catastrophic consequences for more homes. Flood in Øyebekken in Kvinesdal.

Pictures courtesy of Alf Magne Midtbø, Powafa.

METHODS

The project uses two sensors, located upstream, and downstream.

Downstream Sensor Location	**Heldalsbekken**
Sensor One: We placed our sensor downstream in a small river by a primary school. This downstream sensor is used to record the pressure levels in a small river located in Kvinesdal. Link to Data: https://app.datacake.de/pd/8cbe38e5-4fbe-4900-9f6b-4049e45b2e74?fbclid=IwAR0WUCwEYbfVZI-5NRbdxBCE514gSExKhhXogpqURu5zxtHfeexp_gMQzfM Project Data is cloud based, located on POWAFA Azure. The above link is real time data.	 Sensor One is conveniently located within walking distance to Coverks, where our database is located, sponsored by Powafa, AS.

Upstream Sensor Location	**Breibekken**
Sensor Two: This sensor was placed by POWAFA-the data from this stream is further upstream, and is shared with Project Current, to provide a baseline of data with which we can compare our downstream data.  	 Breibekken is located upstream from the town of Kvinesdal. The second sensor is located downstream, in Kvinesdal, in Heldalsbekken.

The transmitter: The transmitter is what sends the pressure levels to the receiver, it's powered by a microcontroller which takes the input from the sensor and uses the transmitter , it operates on a 11.5V battery which needs to be changed every 10 days. Because the transmitter is what consumes most of the battery power it is activated every 5 minutes to be more efficient and less battery consuming.

The Receiver: The receiver puts the data into an excel document, the data received includes Sensor ID, Value MM, Reading ID, and Time (date).

MATERIALS

COMPONENT	FUNCTION	LINK
Water pressure sensor 	Sends an analog input to the microprocessor every 5 minutes. The data from the sensor is sent via the LORA Wan server to a SQL database located in Coverks in Kvinesdal. Our project is a pilot project hoping to inspire other students to collect data using our methods with data sent to our Kvinesdal database, or a database of their own choosing.	https://www.powafa.no/powafa-abonnement/ (Information on the sensor from POWAFAS AS) Pressure Sensor: https://www.ebay.com/itm/392899885503 Components can also be found on Things network: https://www.thethingsnetwork.org
Radio component (LORA transmitter)	It sends a radio signal to POWAFA, so we can collect data. The LORA i/o controller operates at a frequency of 868 mhz.	RF-LORA: The 50km Radio Module (rs-online.com) Link LoRaWan i/o controller: https://www.electromaker.io/shop/product/lt-22222-l-lora-io-controller-support-eu868mhz-frequency
STM32 Microprocessor	Microprocessor - Takes the input data from the sensor and uses the radio to transmit the information to Coverks.	https://en.wikipedia.org/wiki/STM32#:~:text=STM32%20is%20a%20family%20of,M0%2B%2C%20or%20Cortex%

 	The data is processed in the cloud on Powafa's Azure cloud database located in Coverks, in Kvinesdal. The STM32 is an ultra-low power microprocessor meeting the power/performance requirements for smart applications. The device can operate from –40 to +85 °C from a battery power supply.	2DM0. The microprocessor is integrated into the Things network. The LoRa Wan server is used to receive the signals -which are then fed into the Things network, a network used by Coverks, the company that cosponsored our project. The Things Network: https://www.thethingsnetwork.org/docs/gateways/thethingsindoor/
11.5 V Battery (5000 mAh) 	Powers the microchip (Has to be changed every 10 days) https://www.elefun.no/p/prod.aspx?v=14518	The battery can be bought at Elefun in Norway or here: lipo battery 11.5v - Buy lipo battery 11.5v with free shipping | Banggood Shopping
POWAFA manufactured box	This is used to connect everything and hold everything in one place	POWAFA – Power and Water Facilitation

What do we do with this data?

All data is sent to Coverks via a radio signal and inputted into the cloud for Powafa where the data is interpreted then sent on to the next stage. Using an open source machine learning AI from thethingsnetwork.org that takes all this information, and learns to predict if there are potential floods, because the location of which we placed the sensor has had a history of having floods. As the AI gets more and more data from the sensor it can become more efficient at predicting floods to the point where we can be notified of a flood hours or even days before it occurs.

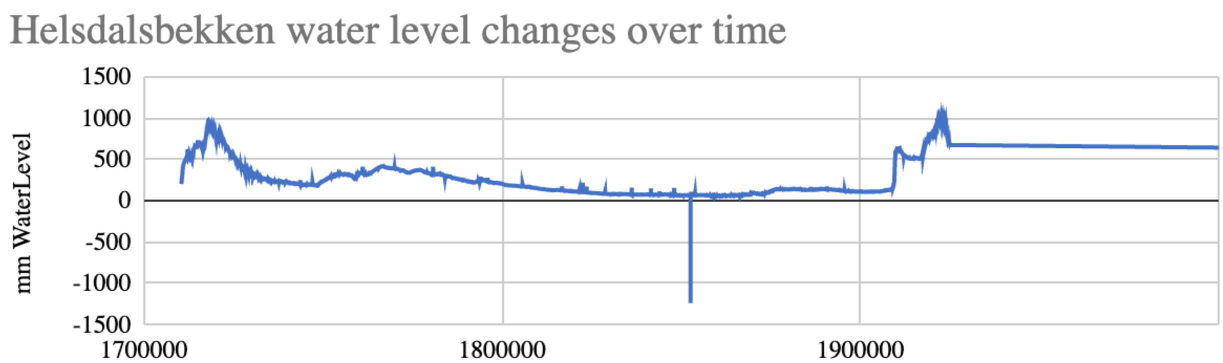
OBSERVATIONS AND DATA

Observations:

Helsdalsbekken Sensor 1 data collected from: 21.01.21 - 01.01.22

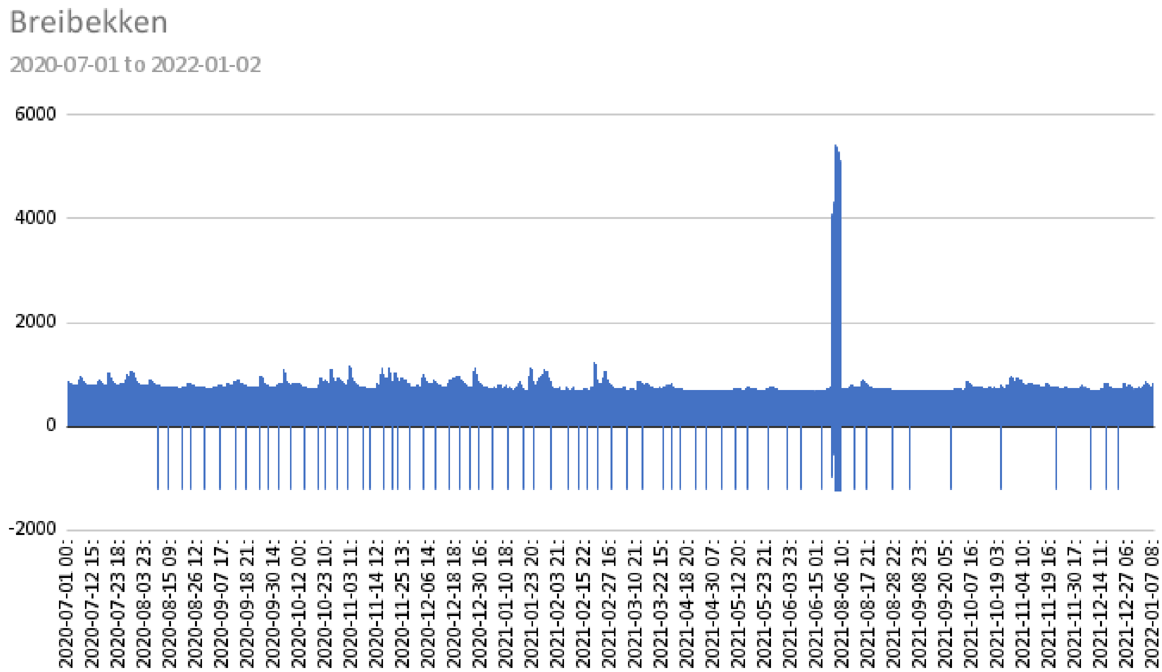
Period of Data Collection	1st of January 2021 - 1st January 2022
Location of Sensor	HELDALSBEKKEN. Kvinesdal https://earth.google.com/earth/d/1cTJ-uASA6aIybIvPXaD-yX8XDGwwKCS8?usp=sharing

At Coverks, Camilla Wagner, a graduate student from France, assisted us in our understanding of the local rivers in Kvinesdal and the resources they provide to the community.



In this chart we can see the water level changes over time. In the X-axis is the Data ID and in the Y-axis we can see the water level. Here we can see that at the beginning of 2021 there was a lot of turbulence in water level, rising to extreme levels then decreasing to very low levels. Over the course of the year's data collection we see the water level gradually decreasing. Close to the end of the year we can see a spout of turbulence beginning again. From this data we could conclude that at the beginning and end of each year there is the potential for flooding in this river, so residents should be aware of this fact. This data is fed into an AI model so with long term data it can make more accurate predictions for inhabitants of the area.

Data from Breibekken is collected in the watertight plastic box, easily mounted, where the battery must be replaced every three weeks.



Above: see 2 year long term data from the Breibekken sensor (we are using data collected by Powafa and their previously placed sensors) - the apparent spike in stream levels on August 6, 2021 is due to changing of the sensor, and not due to an increase in water levels. However we can see regular rising in water levels roughly twice monthly. This tells us that this area is likely to get regular rain which increases the water level and if water levels rose enough it could potentially flood the road and the Barnehage that is near the river.

CONCLUSIONS

This project's goal is to predict floods in the sensor placement area after long term data collection is imputed into a machine learning algorithm. The water sensor will be able to effectively predict floods hours before they occur. For this to happen the water sensor must send enough data over time and use that data to develop an AI model that can learn to predict floods. The purpose of the project is to predict floods and help ensure safety of those vulnerable to the predicted floods.

State the results:

From the data from Sensor 1 in Helsdalsbekken we can conclude that at the beginning and end of each year there is the potential for flooding in this river, so residents should be aware of this fact. We can also see that there is a decrease in water level throughout the year. In the data from the Breebekken sensor (Sensor 2) we can see regular rising in water levels roughly twice monthly. This tells us that this area is likely to get regular rain which increases the water level and if water levels rose enough it could potentially flood the road and the Barnehage that is near one of the streams.

Connect the results to the main project:

The results show the effectiveness of the sensor. This means placing another sensor in a different location could reach the goal of the main project, and enable the user to predict floods with the two sensors. This is exactly what the main project aims to do, gather data and use the data with AI to predict floods within a matter of minutes.

FURTHER DEVELOPMENT

The project could be expanded to multiple areas in local and global locations. Multiple sensors can be placed in other local areas that are prone to floods. The project can be expanded to seas, rivers, streams and in locations in countries such as India, that experience floods during the summer monsoon season. There is usually a large amount of rain during the monsoon season, and there are many floods in different places around India. The water level sensor can predict, through machine learning and AI, sea level changes due to global warming, this can allow us to track both the progression of global warming and what we need to do to improve and reduce further sea level rising. With this technology countries can find a solution to potential upcoming floods (Such as evacuating the people etc). Other locations such as the Philippines experience flooding which are due to increased water levels. The small projects could help predict flooding and improve the efficiency of safety precautions all over the world. Especially with the climate crisis that is currently happening around the world.

SUPPORT RECEIVED

We received support from our teacher and supervisor Per Olav Verås. Due to the Covid restrictions at the time we were unable to go to Kvinesdal to place the sensor. Our teacher Per Olav Verås , and Alf Magne Midtbø from Kvinesdal, placed the sensor for us. When Covid allowed it, a student's mother drove us to Kvinesdal to learn about the sensor and replace the sensor's battery. We received support from Alf Magne and Powafa, and he explained how the batteries are changed and what the sensor was built to do. The sensor was interesting to learn about, and he explained everything that we needed to know. Powafa provided us with the necessary equipment we needed and allowed us to use previously collected data from up to two years ago. Powafa also provides services to the Norwegian Environmental Agency.

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