Offer
IHM — Intelligent Health Monitor

algorithmica technologies

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This is the scope of work description for the software product Intelligent Health Monitor (IHM) of algorithmica technologies Inc. Please refer to your personal offer letter for the prices of the items described herein. The commissioning of IHM is usually done in four phases that are described in detail here.

1. Point of Departure and Goal

You operate a **various pieces of machinery** (such as gas, steam, or wind turbines, compressors, pumps, heat exchangers, chemical reactors and so on) which may or may not be in a state of good health. You wish to determine, continuously and at any moment, the state of their health and an indication of what may be wrong with their health.

An empirical data model constructed by an automatically learning system is to support the maintenance crew in order to better plan and execute maintenance activities so that unplanned outages are reduced to minimum.

algorithmica offers a **predictive maintenance software** that can determine the state of health of any equipment that is appropriately instrumented. We call this the Intelligent Health Monitor (IHM). Section 2 will provide more information about IHM.

You wish to use IHM to alert you about necessary maintenance activities **well before they become emergencies** and so to avoid unnecessary downtime, production loss, emergency work, and collateral damage.

2. IHM Product Description

IHM consists of two mathematical modules.

The (1) **Machine Learning Module** obtains the differential equation that describes the dynamics of the equipment accurately. Of all the sensors on an equipment, we choose several indicative ones to receive models. These models are trained using historical data for which the equipment was known to be healthy. The models thus encapsulate the definition of health for this equipment.

The (2) **Maintenance Module** uses this equation to determine the current state of health of the equipment by comparing the current measurements against the models. If they agree (within a confidence interval), the definition of health is obeyed and the equipment is in good working order. If they disagree, then the equipment is unhealthy. Depending on the sensor that causes the disagreement and the degree of deviation, we may conclude both the severity of sickness as well as its location. This leads to an alarm that is sent by email to a specified list of recipients.

Dr. Patrick Bangert, CEO
p.bangert@algorithmica-technologies.com
m +1 408 707 0956

algorithmica technologies Inc.
10870 North Stelling Road, Suite 39B
Cupertino, California 95014
USA

Board of Directors:
Patrick Bangert

Delaware File: 6037242
HBS Record ID: 304797

In addition to the mathematics, IHM offers an **interface** to periodically read the current data from some data source such as the control system. This interface uses the industry standard protocol OPC.

A browser-based user interface allows the users of IHM to access the software from their desktop computers. They can then look at models and alarms as well as make changes. The software supports the commenting, categorizing and reporting on alarms so that IHM can be used to administrate and document maintenance activities.

3. Project Procedure

IHM is a **standard software product** that can be installed just like any other software. In addition to the software, you require the dynamic models of your equipment. These models are specific to your equipment and must be made for you.

In order to produce these models, we need historical data as well as **some information** about the measurements on the equipment. These data will be gathered together with you in a workshop.

3.1 Phase 1: Preparation

First, we collect some **information about the equipment and the individual measurements**. We are preparing two files. One file will contain the historical values of all measurements for the last few months and the other will contain information about each measurement. Please see the precise requirements in section 5 of this document. We will also define which of the tags are to receive models and will therefore receive alarms.

Typically this phase requires two days of effort and is usually done in the context of a two-day workshop conducted by algorithmica with you at your site. Optionally, you may choose to gather this data on your own according to the specifications given by algorithmica.

3.2 Phase 2: Modeling

As soon as the data of phase 1 is available, **modeling** can begin. This initial model creation cannot be done fully automatically as some restrictions must be programmed manually and the learning methods must be parameterized to your particular dataset. A few days of effort on the side of algorithmica are required to perform this work. Due to delays caused by communication and computation times, we estimate 4 - 6 weeks of duration for this phase.

You will obtain a **report** with sample alarms and a quantified overview about what would have happened if IHM had been in operation in the past. This report can be used as the basis on which to decide to install IHM.

3.3 Phase 3: Implementation

This phase will install IHM in your plant for real-time use.

3.3.1 Phase 3.1: Installation

The IHM software will be installed on a server of your choice. Please refer to section 5.4 for the technical requirement of the server. The installation is performed using a normal installation software and takes approximately 1 hour. The setting up of the connectivity to the data source and the network of users may require additional effort.

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3.3.2 Phase 3.2: Fine-Tuning

The model is usually not yet ready to deliver fully correct alarms because a few pieces of information from phase 1 (preparation) were forgotten. We thus go through a list of historical alarms together and compare them against known problems on the equipment. This is used to improve the models by changing some of their parameters and re-training them. This usually requires 4 days.

3.3.3 Phase 3.3: Testing

The project can now progress to the **real live test** in which the alarms are actually sent out and examined by human engineers. If additional changes to the models are necessary, algorithmica will of course make them quickly. If not, IHM will run as normal and alarms will result in examination by human experts and may result in actual maintenance activities. After a period of one month, the test results will be examined and the **success of the test determined**.

3.4 Phase 4: Usage

At this point, the project of introducing IHM to your plant is over and the **normal usage** of the software can continue. This usage ends the license agreement for the testing phase and begins the license agreement for the normal usage phase for which a license fee must be paid.

4. Pre-Requisites for IHM

IHM assumes that…

- Your equipment is sufficiently instrumented that all important physical quantities that determine its health are available.
- All data is available from one data source, typically the control system.
- All data has been archived for a long period of time, usually at least several months, in some data historian.
- The current data can be accessed via the OPC protocol.
- There are persons who will receive the alarms.

5. Technical Specifications

5.1 Table of Metadata

In phase 1.2 you will collect a **list of all measurements** that are important for the health of the equipment. We suggest that you begin with an empty list and add one-by-one those tags that are important. Having obtained a list of all necessary tags, you will then need to collect certain information about each of them. This is specified in a separate document.

5.2 Historical Data

To learn the dynamics of your equipment, IHM need historical data. Typically **several months** are a good amount. Generally, more data is better for model quality and health detection. The file format for this data is specified in a separate document.

5.3 Alarms

Among the list of all tags, we choose a number of them to receive models. Only modeled tags will get alarmed as these are the only tags where a model can deviate from the measurement. These must be identified as those tags that are most indicative of poor health for that equipment. This

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identification should be done by an experienced maintenance engineer for that equipment.

5.4 Computer Hardware

IHM will run on a computer of your choice in your plant. You data will thus be held locally without any direct connection to the internet. The computer can be a hardware or virtual computer. The system administration will be provided by your IT department. The computer must fulfill these criteria:

1. Microsoft Windows 64-bit operating system
2. Account for algorithmica with administrator privileges
3. Hard disk capacity at least 1 TB
4. Memory at least 8 GB
5. Processor at least Intel i7 920
6. We suggest a RAID system against hard disk failure
7. We suggest a regular data backup strategy
8. Access to the OPC server; may require fire walls to be configured
9. Access to the office network; may require fire walls to be configured. IHM provides its browser-based user interface on port 3000 of the server.
10. Remote access for algorithmica when needed for help

6. Project Management

Section 3 describes the principal project process. algorithmica will guide you through all aspects of this process that have to do with data, mathematics and IT.

In addition to the technical steps described here, such a project contains operative changes in the organization of the users to be discussed, planned, documented, implemented and maintained. This **project and change management** component is not covered in this document. It is assumed that you will provide this work in house. If not, algorithmica is happy to connect you to several consulting companies that provide this service in cooperation with algorithmica.

7. Commercial Terms

The client organization will name a **project manager**. The project manager will have the authority to make decisions regarding budget.

Until the decision has been made to use IHM for normal operations and the license fee has been paid, the IHM software and all models remains the property of algorithmica. The project itself will be billed and paid for according to the number of effort days used by algorithmica. algorithmica will bill the number of days used up at the end of each calendar month.

All work will be billed on basis of a daily rate where one day consists of eight hours. The work will generally take place in the offices of algorithmica. When algorithmica works on-site with the client, algorithmica will bill a travel flat rate per day of travel. This includes all costs of transportation, accommodation, food, insurances and so on.

Optional items are not contained in any estimated project efforts and may be billed separately. Our payment terms are 30 days. All prices are net prices without any sales or value-added taxes that may or may not be applicable depending on the location of the client's organization.

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8. Legal Terms

algorithmica retains the right to cite this project and the client as a **reference** in the future. It is furthermore our goal to publish the results of projects in the **scientific literature** together with our clients. Of course, any non-disclosure rules and regulations will be obeyed.

It is expected that both parties sign a **non-disclosure agreement** prior to starting work on this project.

Before APO can be used in your plant, a **license agreement** must be signed. During the trial phase, this license will be supplied free of charge.

algorithmica accepts **no liability** whatsoever for any damages that results from the use of its products. All software of algorithmica supplies information only and can therefore cause no direct damage of any type. The decision to engage in some action on the basis of this information is in the responsibility of the persons making this decision. Any claims of production loss, product damage, machine damage, collateral damage or any form of physical or non-physical damage are excluded.

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