EASILY ACCESSIBLE INTELLIGENT CORROSION TOOLS ON THE INTERNET

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Web Accessible Intelligent Tools
Summary

- Present day AI corrosion applications
- Present day internet applications
- Melding “intelligent” corrosion applications with the internet – Our Goal
- How these applications work
- Conclusions

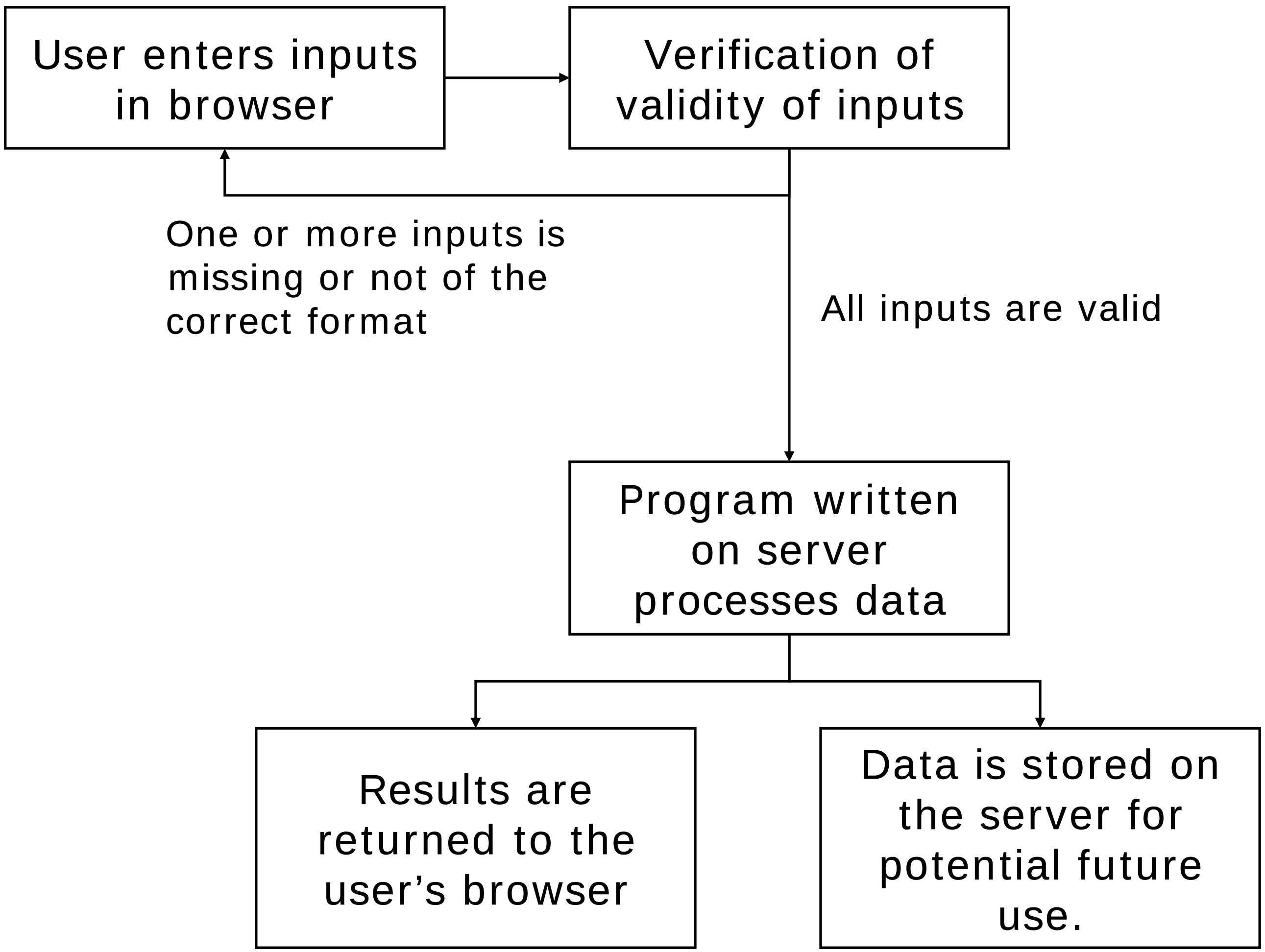
Present Day AI Corrosion Applications
Simple but not easily portable

- AI/Expert System data classification
  - Lab data and plant observations for same system
  - Literature data and lab data for "same" system
  - Data from two lab techniques for same system
- Single user or multiple users in one site
- Usually only designed for Windows
- Windows "compatible" means multiple operating systems "compatible"
- User feedback issues
- Update development and distribution issues

Present Day Internet Applications *Incorporates a number of languages*

- HTML provides the user interface
  - Usually readable in all browsers
  - Independent of operating system
- User inputs must be verified
  - Must be of the right type (number, string, etc.)
  - Must be within a certain range
- CGI scripting language performs calculations
- CGI scripting language returns HTML formatted pages to the user

Present Day Internet Applications
Information path overview



Present Day Internet Applications
Strengths of internet applications

- Platform independent
- Only require web browser compatibility
- Central server for multiple sites
- User feedback in common format
- Shorter lead time for improvements
- Fast update distribution (central server)
- "Collective Corrosion Experience" more easily captured

Melding Corrosion Applications with the Internet
POLEXPERT & SEQEXPERT as examples

Prediction from Cyclic Polarization Scans

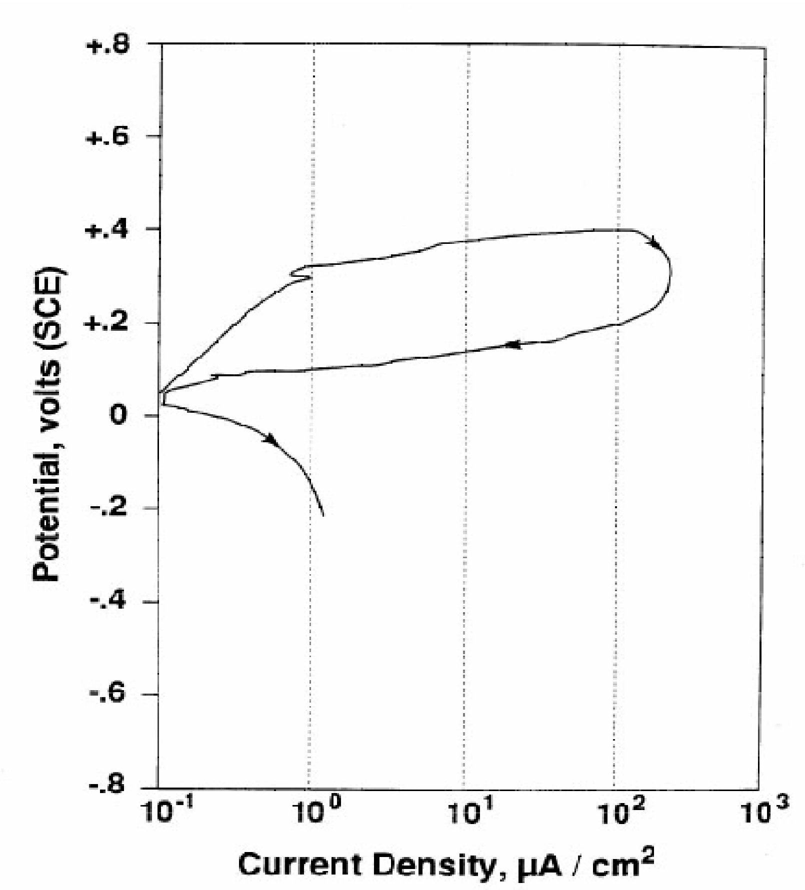
- Artificial Neural Network trained from laboratory and field data
- Polarization scans measured in laboratory (or plant)
- Input information - values or attributes from lab measurements
- Trained network has weights used to assess crevice and general corrosion and pitting
- Expert system interprets values and provides usable output

Prediction from Sequential Immersion Test

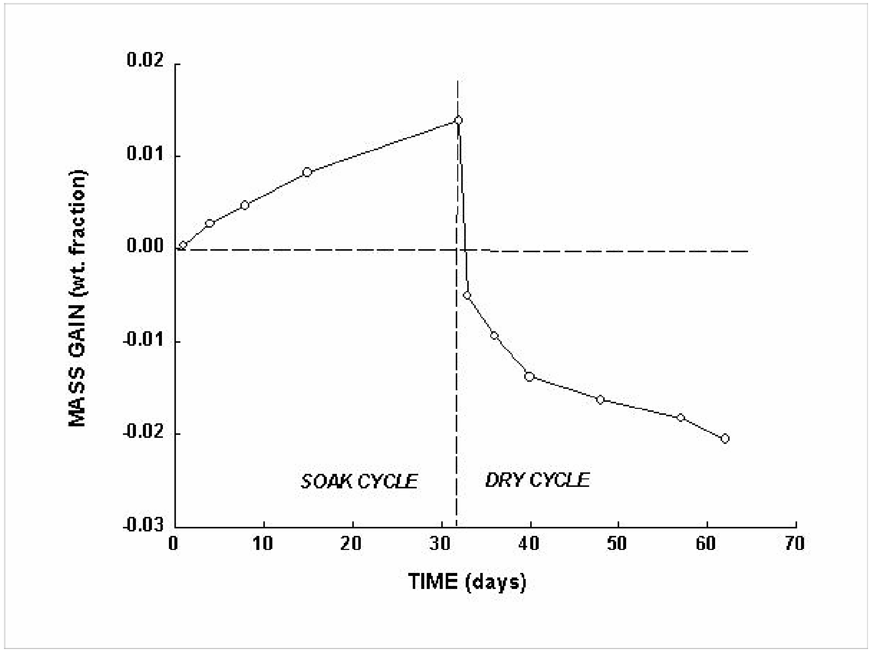
- Artificial Neural Network trained from laboratory and field data
- Mass vs. time and hardness change measured in laboratory
- Input information – values or attributes from lab measurements
- Trained network has weights used to assess chemical compatibility
- Expert system interprets values and provides usable output

Melding Corrosion Applications with the Internet
Experimental information required

Example of Cyclic Potentiodynamic Polarization Scan (Alloy 20 in process)



Example of Sequential Immersion Test (EPDM in waste stream)



Hardness before and after experiment is additional measurement

How These Applications Work
Basic flow of the internet applications

Enter web site from internet.

Enter Artificial Neural Network–Expert System Area

Enter name, company, and email address

Enter the parameters such as the type of material, the appearance of the material, and requested parameters from the test being run

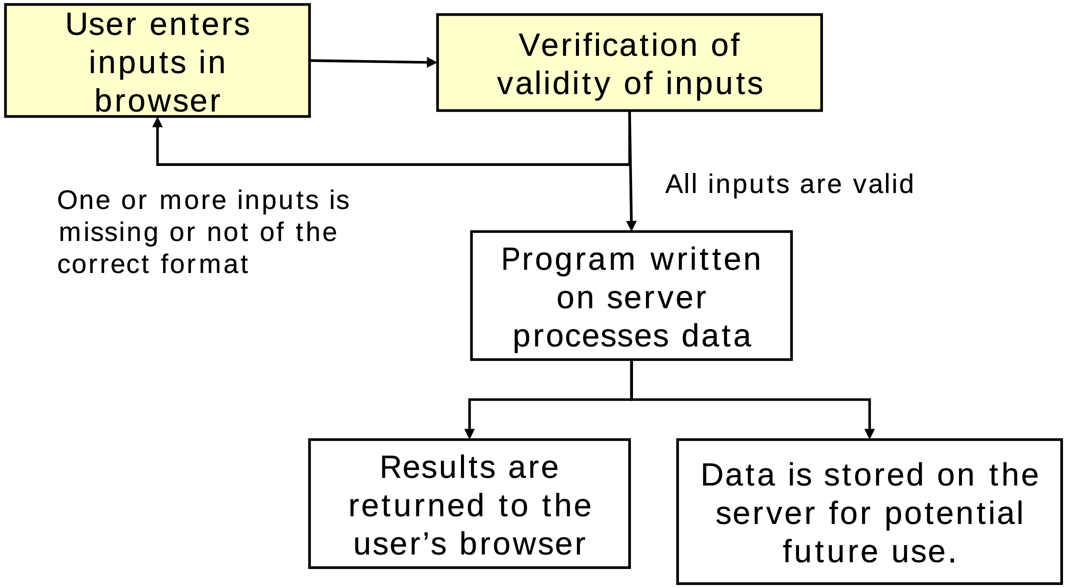
Artificial Neural Network calculates values corresponding to compatibility between material and environment.

Expert System uses logical rules to combine the outputs from the Artificial Neural Network, and other parameters to give a qualitative assessment of the compatibility of the material with the environment .

Easily understood text provided to user as output.

How These Applications Work
HTML and Javascript used for user inputs

- An HTML form is displayed to the user for data input
- Javascript embedded in the HTML verifies that all fields are entered and that all inputs are valid
- A pop up window displays any errors
- Only the incorrect user inputs need to be reentered



How These Applications Work
Example of inputs

Cyclic Potentiodynamic Polarization Scan

Feature	Value or Quality of Feature
Repassivation or Protection Potential	(repassivation potential - corrosion potential)
Pitting Potential	(pitting potential - corrosion potential)
Potential of anodic-to-cathodic transition on reverse portion of scan	(potential of anodic-to-cathodic transition - corrosion potential)
Hysteresis	positive, none, negative
Current density at corrosion potential (labeled "passive current density")	Estimate of current density that best reflects its value at the corrosion potential
Active-Passive Transition or Passivation Potential	present, absent
Scan appearance	Chosen from one of 4 sample scans
Electrode appearance	Chosen from one of several descriptors

How These Applications Work
Example of inputs

Sequential Immersion Test with Hardness

Feature	**Value or Quality of Feature**
Mass (or weight) fraction change during soak portion of test. (Final weight minus initial weight divided by initial weight)	-1<mass fraction<1 (negative signifies mass lost during exposure to test environment
Mass (or weight) fraction change during drying portion of test. (Final weight minus initial weight before test divided by initial weight)	-1<mass fraction<1 (negative signifies mass lost during drying
Final curvature of profile during soak portion of test (qualitative judgment)	Far from equilibrium, Near equilibrium
Final curvature of profile during drying portion of test (qualitative judgment)	Far from equilibrium, Near equilibrium
Sign of final mass minus initial mass after soaking	Positive or negative
Sign of final mass after drying minus initial mass before start of test	Positive or negative
Overall change in hardness	Difference between actual values read
Sample appearance	Chosen from one of several descriptors

How These Applications Work
Inputs as displayed in HTML

- Displaying inputs is user-friendly with HTML
- Selecting inputs is straightforward

<u>Electrode Appearance</u>

Please examine your electrode for corrosion and identify the description most consistent with your electrode appearance. If two types of attack are present, pick the most sever of the two. This answer will be compared to the type of polarization scan selected in Step 2 to provide an initial consistency check. The answers will also be compared with the prediction made by the artificial intelligence system.

Examine the electrode carefully. Enter the best description shown.
Help on this topic

- ○ No Attack
- ◉ Localized Corrosion
- ○ Discoloration
- ○ Other, please specify:

<u>Non-metallic Specimen Appearance</u>

Does the sample show any signs of degradation?

Enter the best description shown.
Help on this topic

- ○ No Attack
- ○ Hardened
- ◉ Softened
- ○ Discolored
- ○ Blistered
- ○ Tacky or other tactile changes
- ○ Crazing
- ○ Other, please specify:

How These Applications Work

Inputs as displayed in HTML

Enter the Repassivation Potential minus the corrosion potential.
(E_{repass} - E_{corr})
0.0 **Volts** Help on this topic

Enter the Pitting Potential minus the corrosion potential.
(E_{pit} - E_{corr})
If there is no pitting potential, enter 10 for the voltage.
0.28 **Volts** Help on this topic

Is there hysteresis between the forward and reverse portions of the polarization scan?
Help on this topic
- (selected) Negative
- None
- Positive

Does the forward portion of the scan exhibit a Passivation Potential?
See the scan example Help on this topic
- Yes
- (selected) No

What is the passive current density?
0.1 **microamp/cm^2** Help on this topic

What is the Anodic to Cathodic transition potential minus the corrosion potential?
($E_{a\text{-}to\text{-}c}$ - E_{corr})
0.0 **Volts** Help on this topic

Enter the weight ratio for the specimen after immersion but BEFORE drying.
(Final Weight - Initial Weight) / Initial Weight
.014 Help on this topic

Verify the sign of the weight ratio after immersion entered above.
Help on this topic
- (selected) Positive
- Negative or Zero

Enter the weight ratio of the specimen after drying.
(Final Weight - Initial Weight) / Initial Weight
-.02 Help on this topic

Verify the sign of the weight ratio after drying entered above. Help on this topic
- Positive
- (selected) Negative or Zero

Enter the final soak curvature. Help on this topic
- (selected) Far from equilibrium
- Near equilibrium

Enter the final dry curvature. Help on this topic
- (selected) Far from equilibrium
- Near equilibrium

Enter the initial and final hardness: Help on this topic

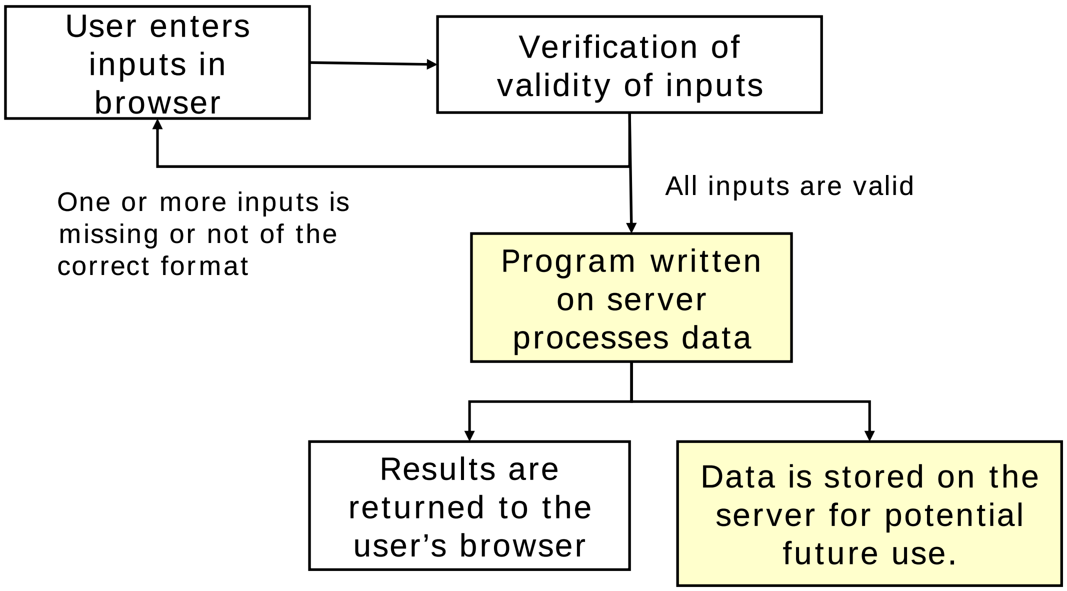
Initial Hardness: 73

Final Hardness: 63

Scale and test device used to measure hardness, for example “Shore Durometer A”
Shore Durometer A

How These Applications Work
Perl used to perform calculations

- CGI language is Perl
- POST method used to pass parameters from the browser to the Perl program
- The Perl program interacts with files on the central server
- Data entered by the user is stored on the central server (e.g a central location)

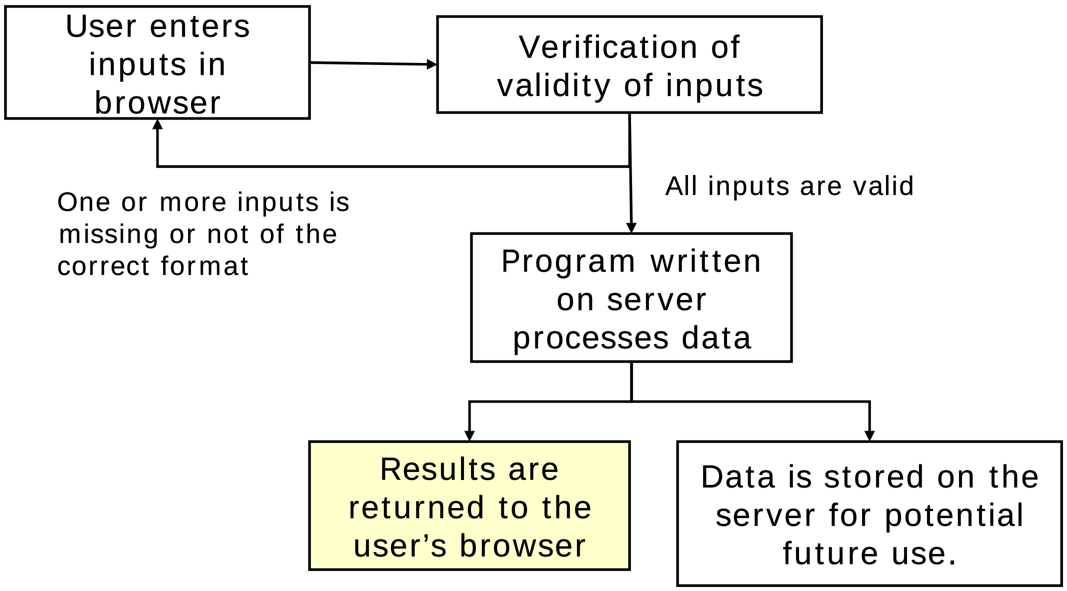


How These Applications Work
Flow of the Perl program

- Decodes inputs from user
- Reads neural network parameters from configuration file for both types of networks
- Calculates outputs for each network
- Performs analysis of outputs based on results from each of the networks
- Writes the input and output information to a file to capture data for future reference
- Writes the output with analysis in HTML format to the web browser

How These Applications Work
Output is returned to the browser

- Recommendation is created from the analysis of the numerical output
- Verbal outputs are formatted in HTML for user
- Feedback form is displayed for questions or comments
- Feedback form can be returned using email



How These Applications Work
Output as displayed in HTML

Cyclic Potentiodynamic Polarization Scan

CREVICE CORROSION PREDICTED
Risk of localized corrosion in the form of crevice corrosion is present. Such areas as close proximity of surfaces, areas under deposits, and metal-gasket interfaces may be prone to such attack. Longer term immersion tests with, for example, artificial crevice formers, are implied to confirm crevice corrosion prediction.

Though general corrosion is not predicted, the general corrosion rate may be at most a contamination rate. If metal ion contamination is important, corrosion rate should be checked by alternative experimental methods.

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Your initial choice of the type of pattern of the polarization scan, the appearance of the electrode, and the corrosion that is predicted from the polarization scan by the artificial intelligence system are consistent with each other.

Sequential Immersion Test

NOT CHEMICALLY COMPATIBLE

The artificial neural network has predicted that this non-metallic material is NOT chemically compatible in the test environment.

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Your initial choice from your visual observation of the sample and the prediction from the artificial neural network are consistent with each other.

How These Applications Work
Capturing data & maintaining security

- Data and results are captured each time the program is run
  - Enables helping of user when feedback is returned
  - Enables retraining of networks using a wider variety of field data
- This approach provides an appropriate amount of security
  - Web server settings protect users from accessing the data files directly through the browser
  - Firewall protects these files from being accessed by other means (telnet, ftp, etc.)

Conclusions
The Present

- Widely accessible web interfaced "intelligent" corrosion tools are feasible
- Tools can be made independent of operating platform
- Complications caused by the operating platform can be circumvented
- User feedback more easily captured in common format
- Updates and bug fixes are installed for all users in one place and take effect for all users instantaneously

Conclusions
The Future

- The internet has pushed trends in how future computer applications may be written
  - Centrally located
  - Accessed remotely by “dummy” terminals
- Lower cost is the driver
  - Fewer developers and decreased skill sets needed
  - Fewer tech support personnel needed
  - Less individual time wasted on compatibility issues
- “Collective Corrosion Experience” will be captured more easily