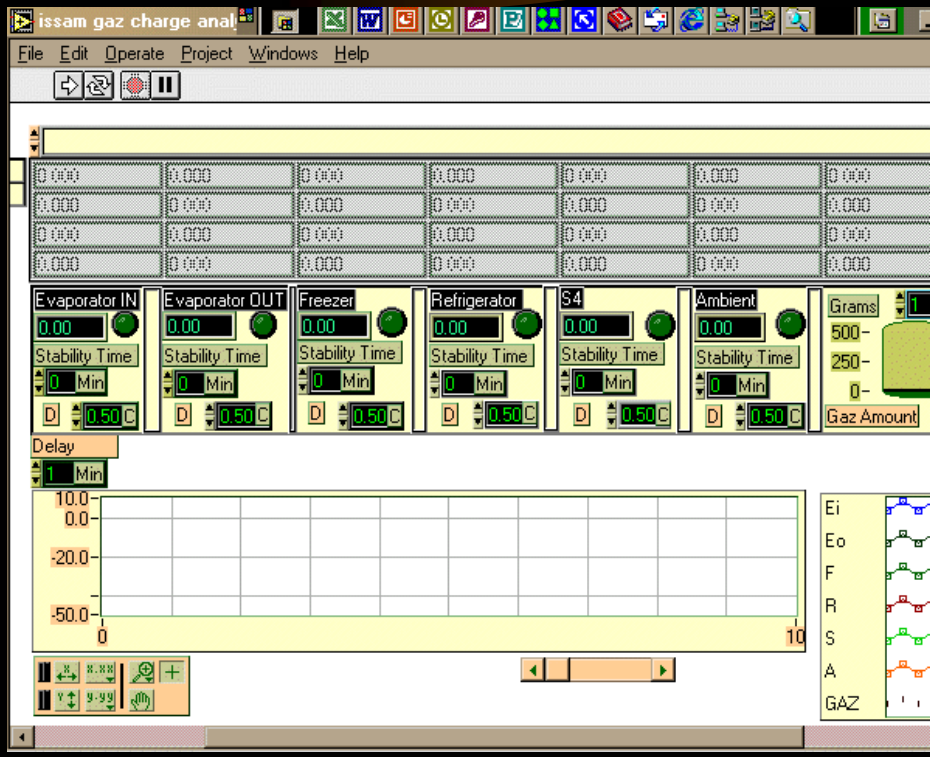
Gas Charge Tester V2.0 FC

"Fuzzy Control"



ERICAN UNIVERSITY OF BEIRUT

Faculty of Eng'g & Architecture

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Graduate School

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What is GCT?

•Performance testing and evaluation of refrigerators is an important stage in the pipeline of refrigerator production, which includes the gas charging.

•The main purpose of the testing is to find the amount of gas needed to attain the smallest possible temperature in as small a time period as possible.

What is GCT?

•This is done by repeatedly adding a specific gas amount and monitoring the temperature change as a function of time.

•Every time an amount of gas is added, the lowest reached stability temperature is to be detected in as small duration as possible.

First Step Toward Automation

- G.C.T. is a project for monitoring and performance evaluation of refrigerators at the manufacturing process.

- Using National Instrument's data acquisition devices and software.

LabVIEW®

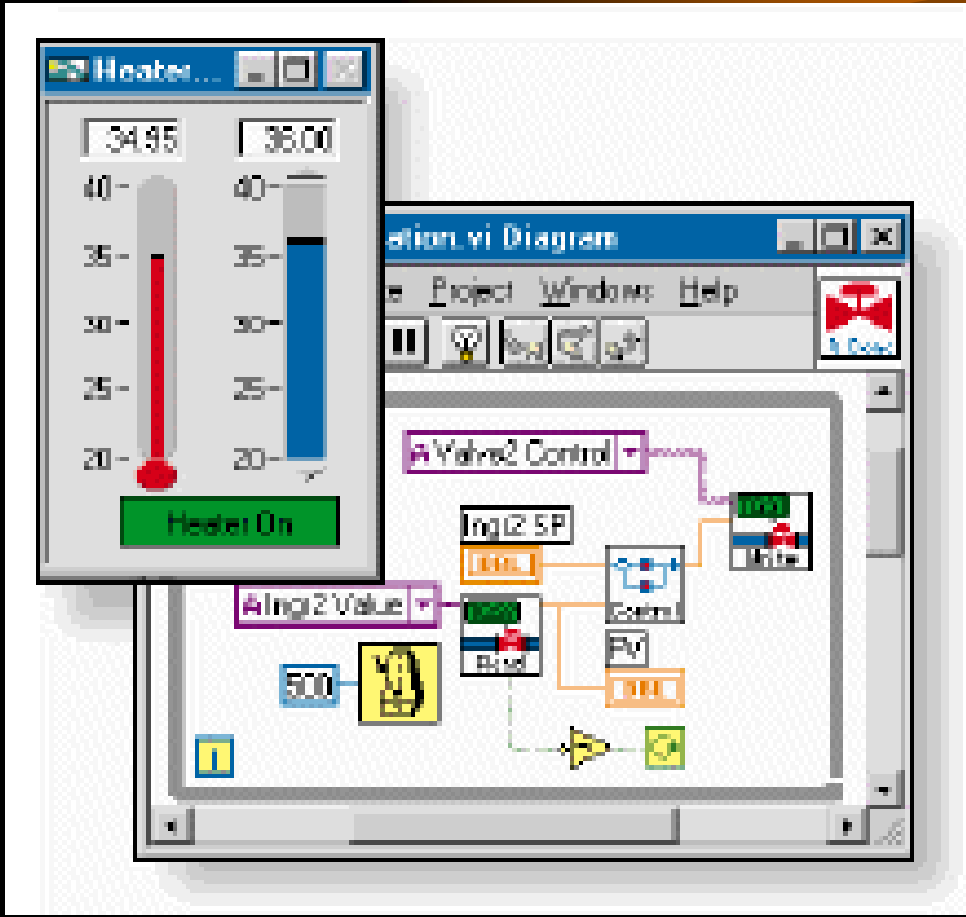
- LabVIEW is a program development application, much like C or BASIC.

- Other programming systems use text-based languages to create lines of code, while LabVIEW uses a graphical programming language, G, to create programs in block diagram form.

Graphical Programming

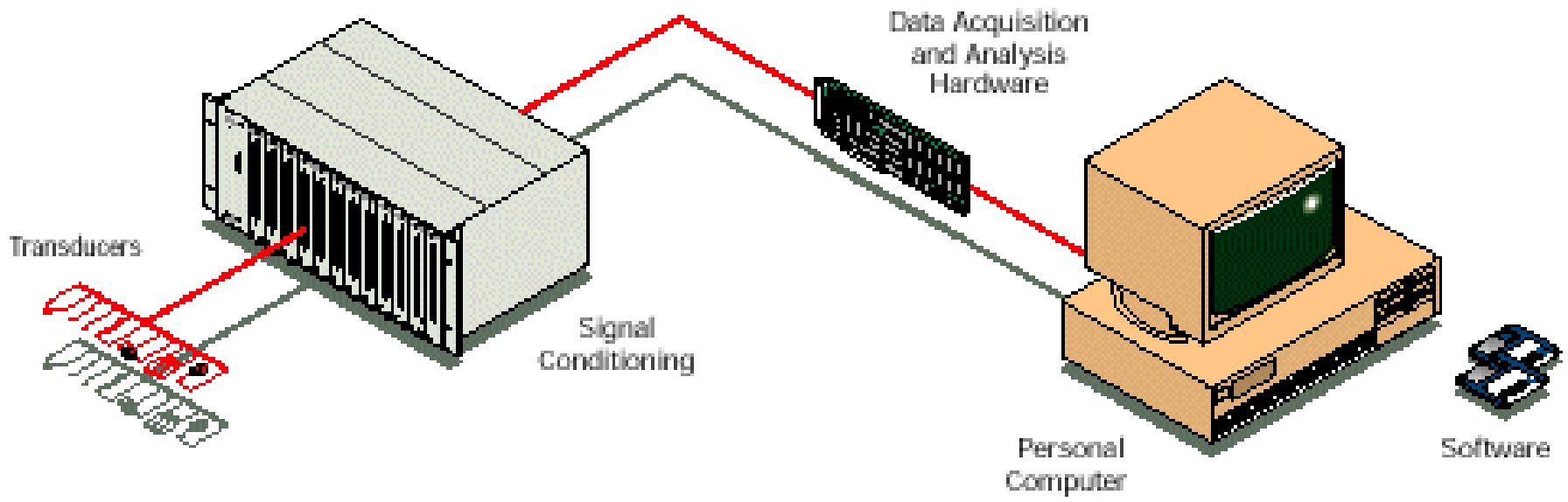
G

G
A graphical data flow programming language.

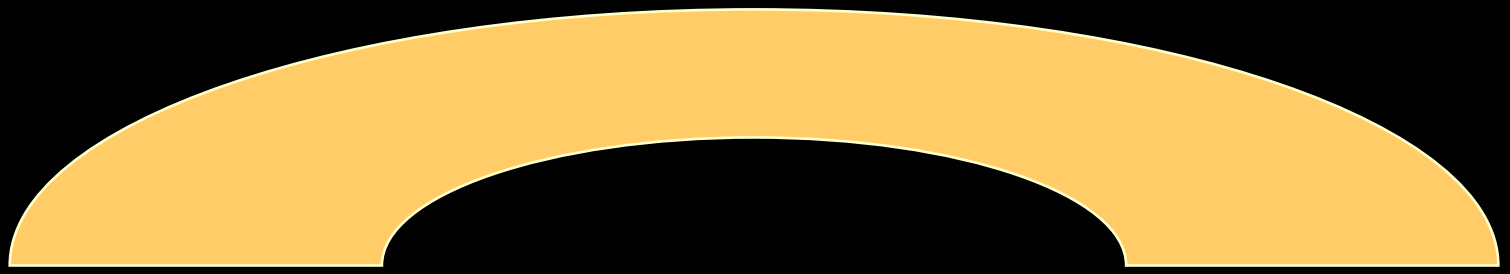


N.I. Products Utilized

*PCI-MIO-16E-4. *SCXI-1300. *SCXI-1000.



The GCT Project



The GCT Scanner

The GCT Analyzer

The GCT Scanner

It is designed to acquire the temperature readings fro
the Thermocouples connected to the NI Hardwa
package.

This program stores these readings in files in order to b
later retrieved and processed.

This program contains 6 charts for each temperatu
sensor to monitor its changes w.r.t. time. A large chart
added to monitor the whole six sensors on a single cha
view.

Different controls are supported to control the acquirin
speed, output files, and delay time.

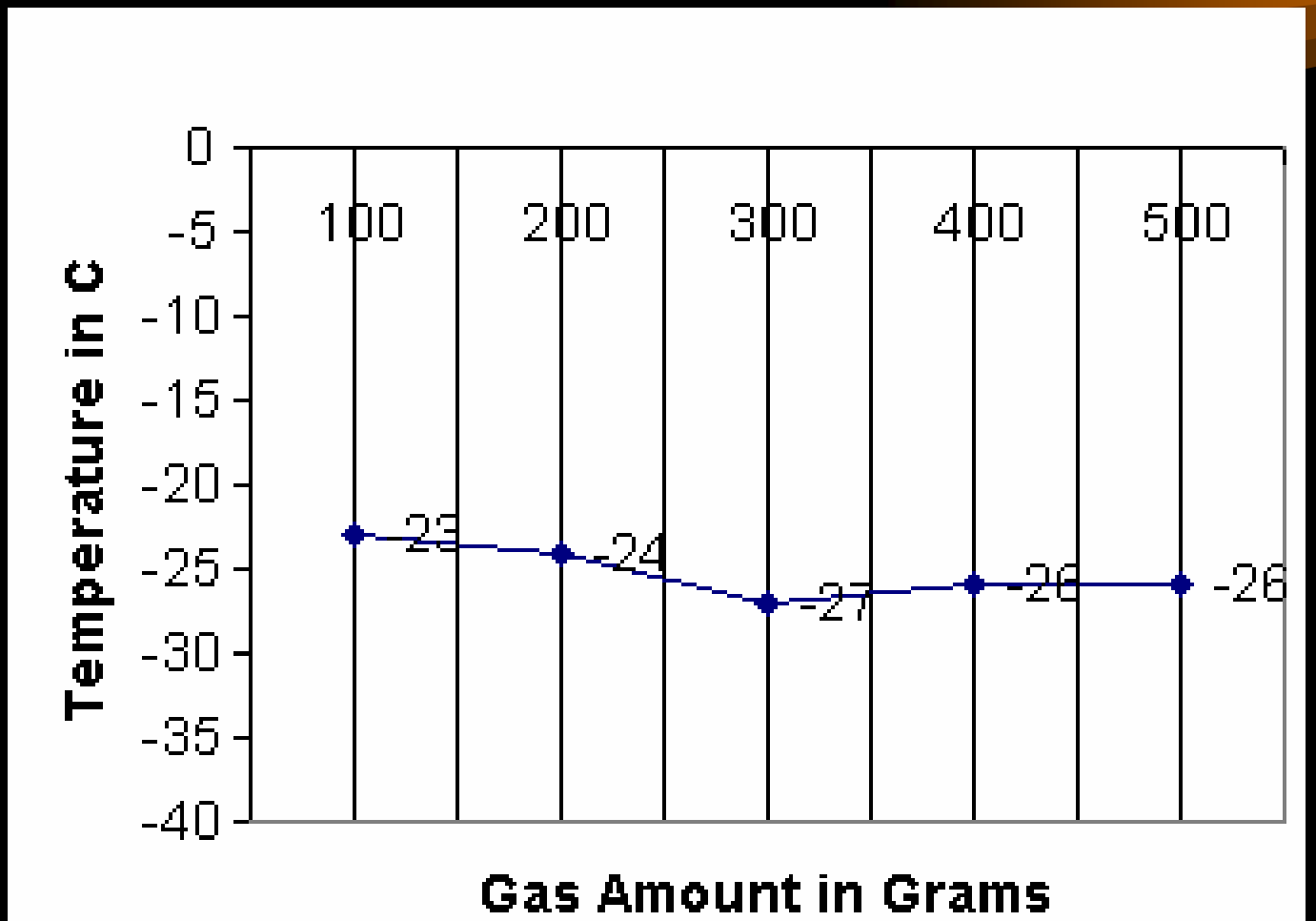
The GCT Analyzer

It is designed to process the data in the files exerted by the GCT Scanner.

Its main purpose is to monitor the changes in temperature readings, and to detect the stability of a certain sensor for a certain period of time at different amounts of gas.

The most suitable amount of gas yielding the lowest temperature would then be found easily.

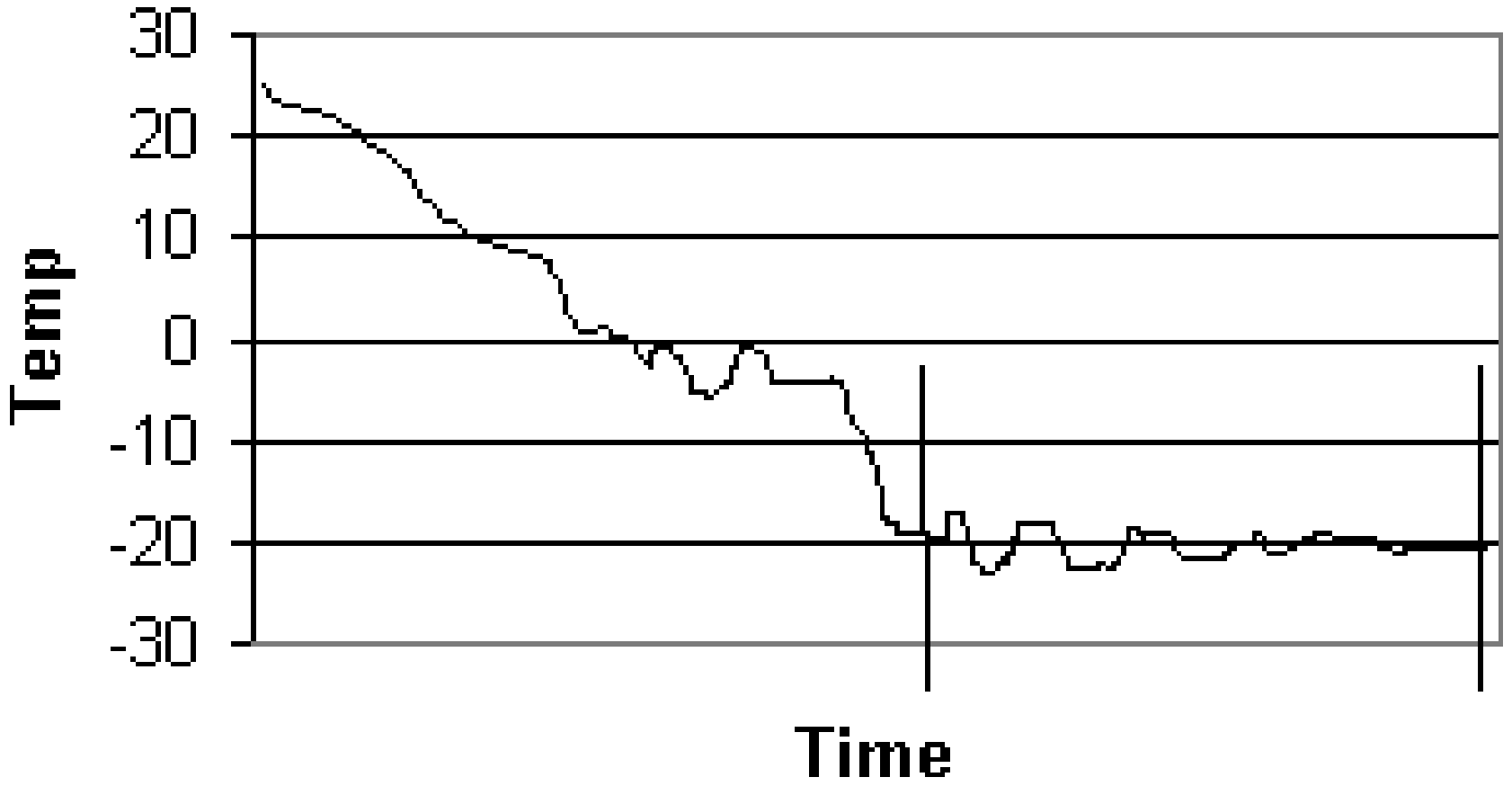
The GCT Analyzer



What is All About The GCT Analyzer with a Fuzzy Controller?

- Due to the trend of temperature change with time, the shorte
he time period over which this change is observed as it start
o become insignificant, the risk of detecting a large
emperature than the one that can be achieved become
igher.

- This problem can be dealt with by devising some sort of
compromise that makes the observation interval fairly
sufficient relative to temperature change to allow for th
detection of the lowest or close to the lowest temperature.

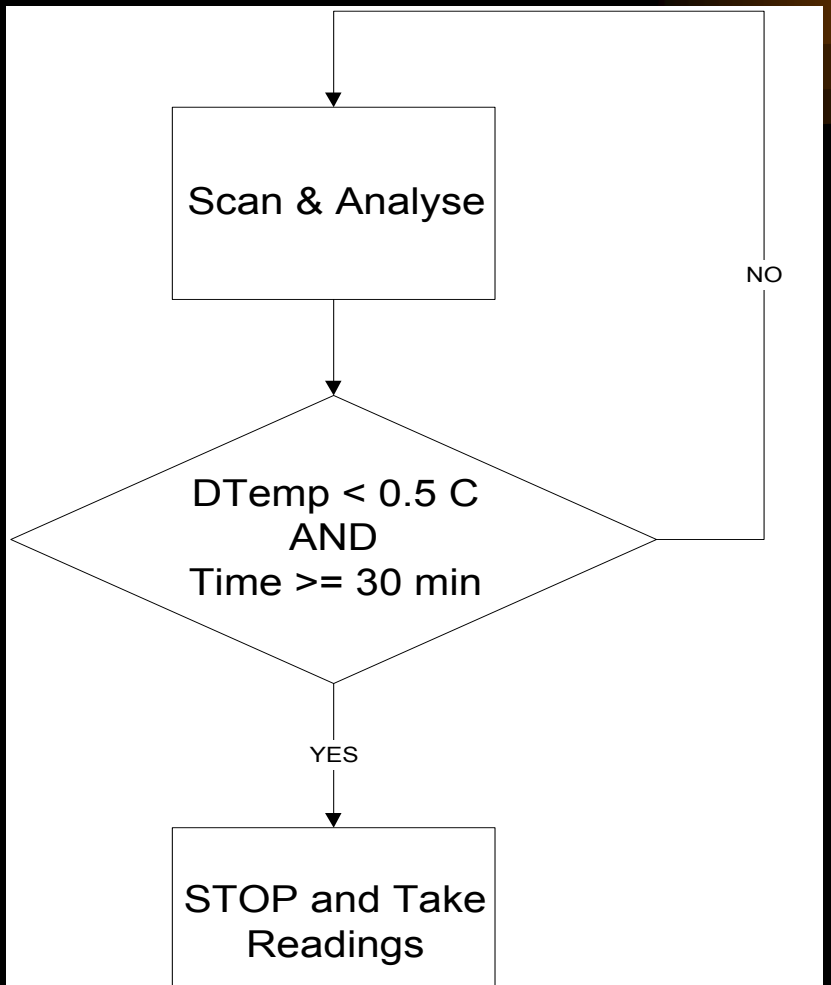

30
20
10
0
-10
-20
-30
Temp
Time

GCT FC

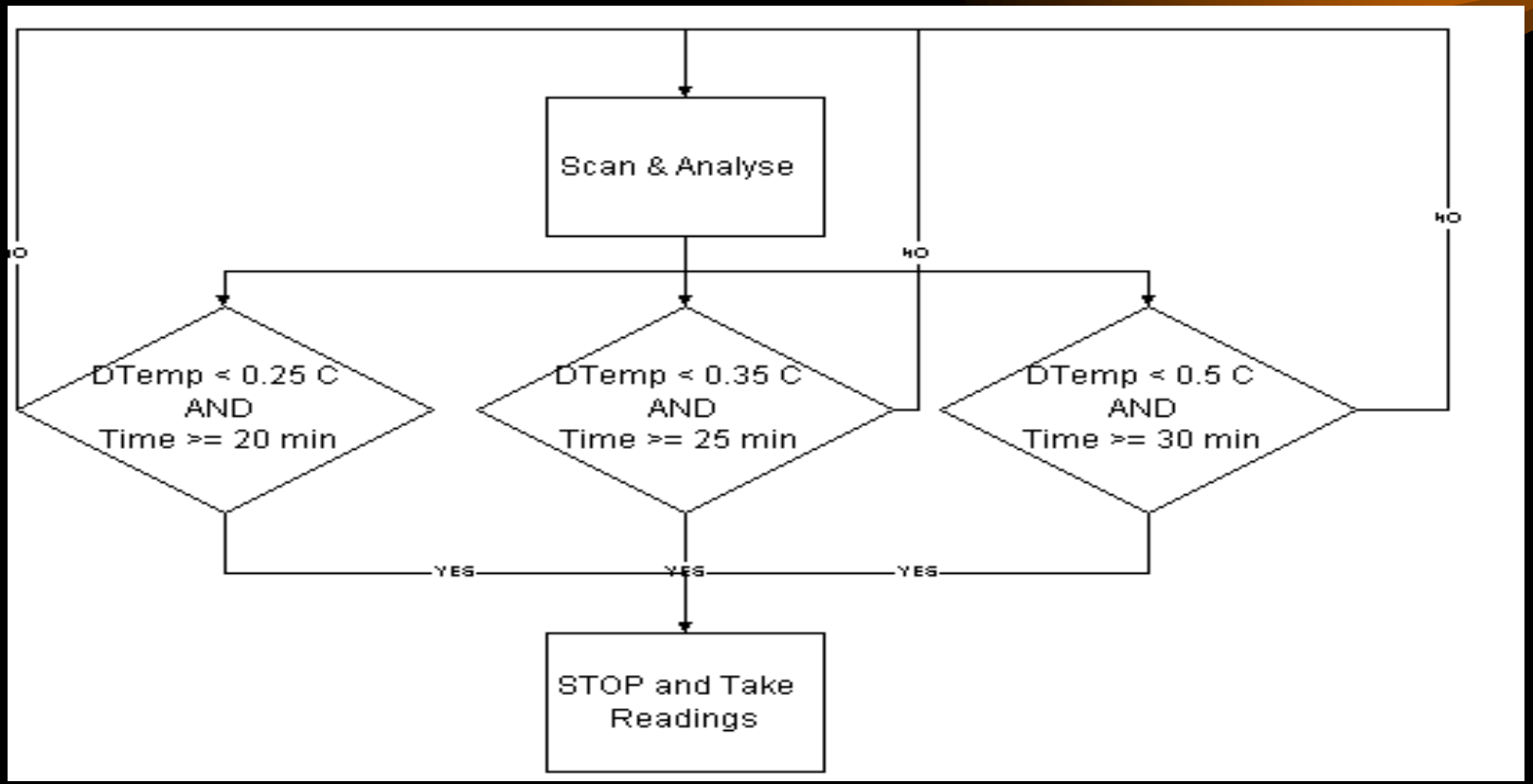
•Given the above noted problem and its devised solution, it appears that an approximate reasoning or a humanistic type of a testing procedure needs to be implemented.

•When the temperature change becomes confined within a specific crisp limit over a time duration that is large enough to leave no doubt about reaching the lowest temperature, a reading of this temperature is taken and another gas amount is added.

First Crisp Solution



Enhanced Crisp Controller



The Fuzzy Logic-Based Solution

•It is clear from the problem statement and suggested solution that fuzziness is embedded in the basic nature of the problem.

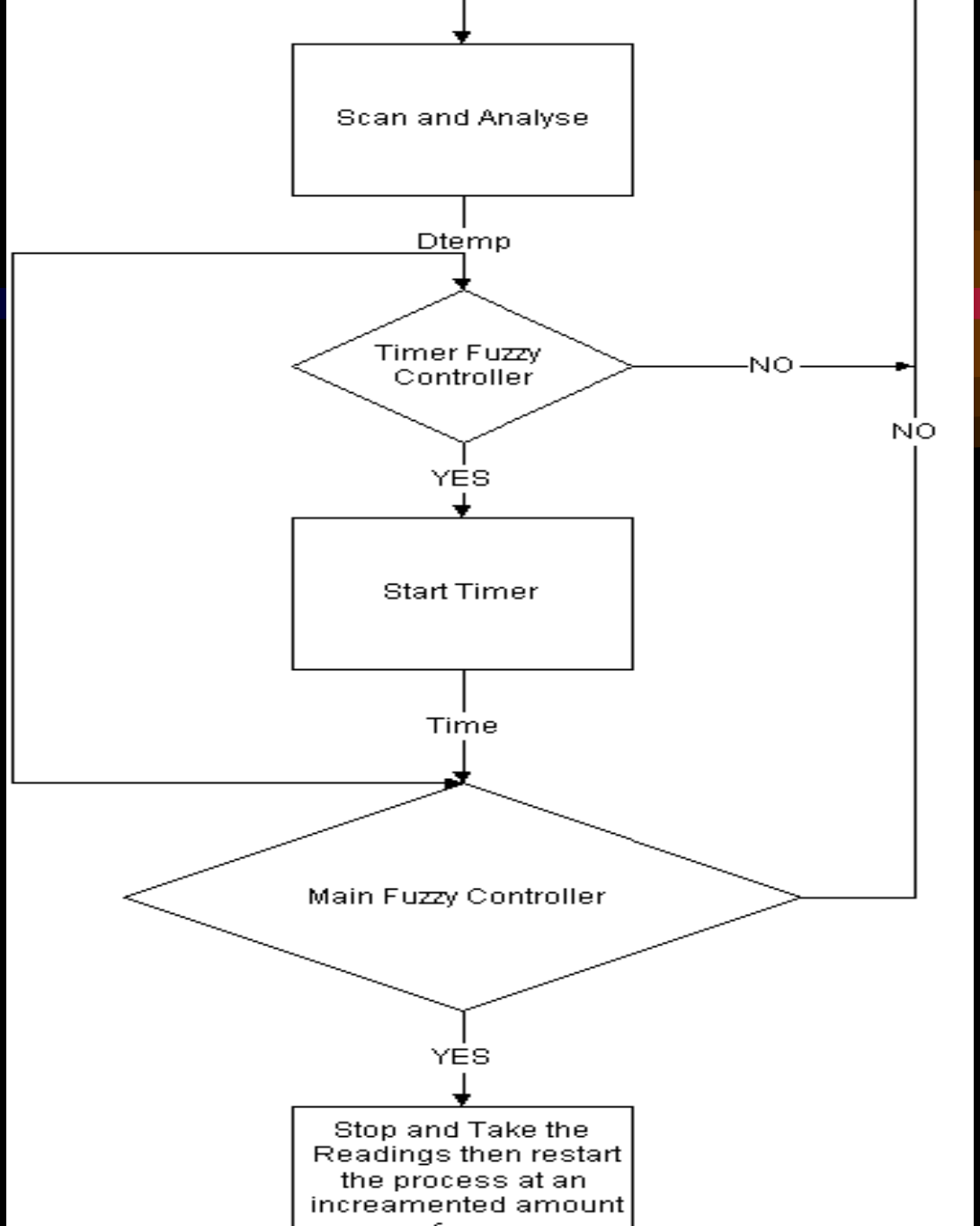
•The approximate type of reasoning involved, the words insignificant, fairly sufficient, close to the lowest, and too much time are fuzzy terms and they can be represented by fuzzy sets.

The Fuzzy Logic-Based Solution

Fuzzy inference rules, which can be used in the fuzzy model solution to this problem, can be of the form:

•If temperature change is large and observation time is insufficient, then testing continues.

•If temperature change is very small and observation time is fairly sufficient, then testing stops.


Scan and Analyse
Dtemp
Timer Fuzzy Controller
NO
NO
YES
Start Timer
Time
Main Fuzzy Controller
YES
Stop and Take the Readings then restart the process at an increamented amount

The Fuzzy Inference Model

- The main fuzzy controller has two inputs Dtemp and Tim
epresenting the change in temperature and the observation o
his change over some period of time. Also it has one outpu
Output It controls the start and stop of the monitoring process

- The membership functions of these variables and the rule
elating them are assigned based on interviews with expert
hat used to work as human operators in the refrigerato
esting process.

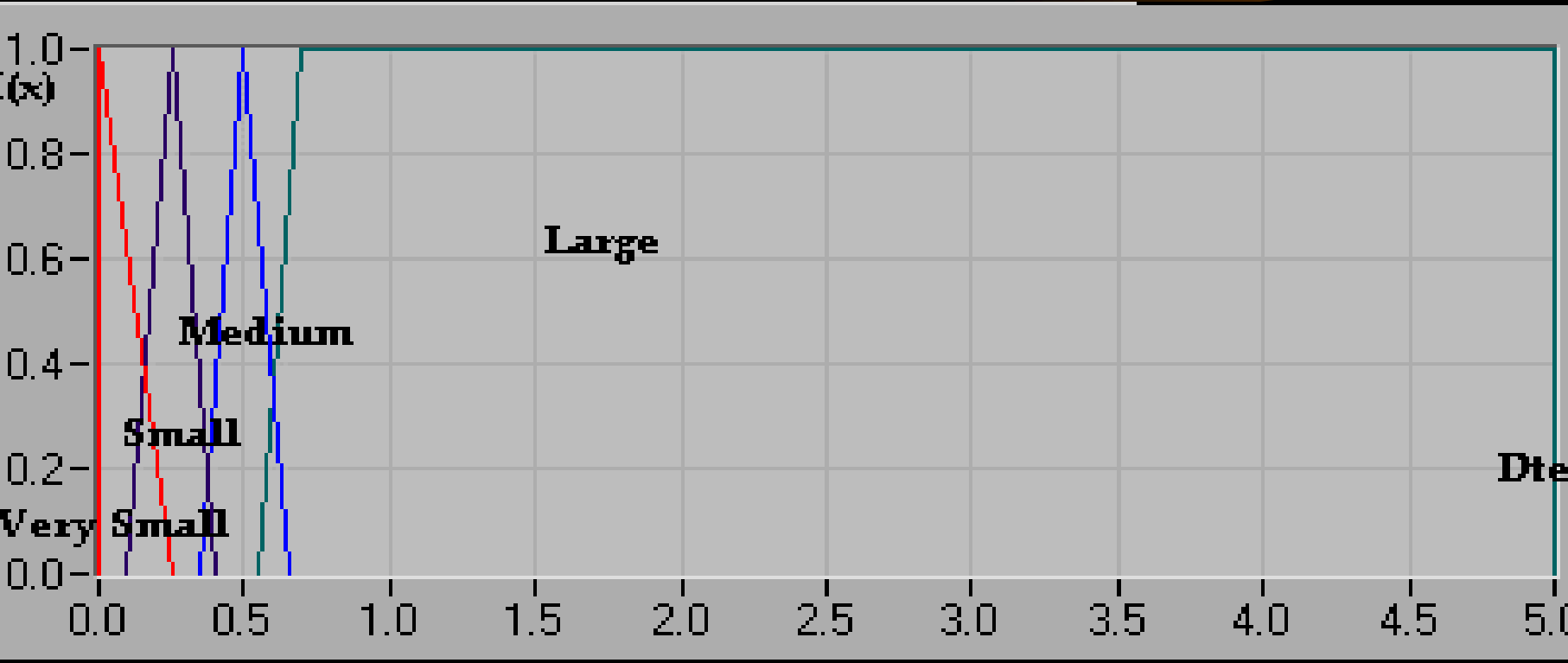
- Tuning has also been done to improve the system to giv
atisfactory results

The Fuzzy Inference Model

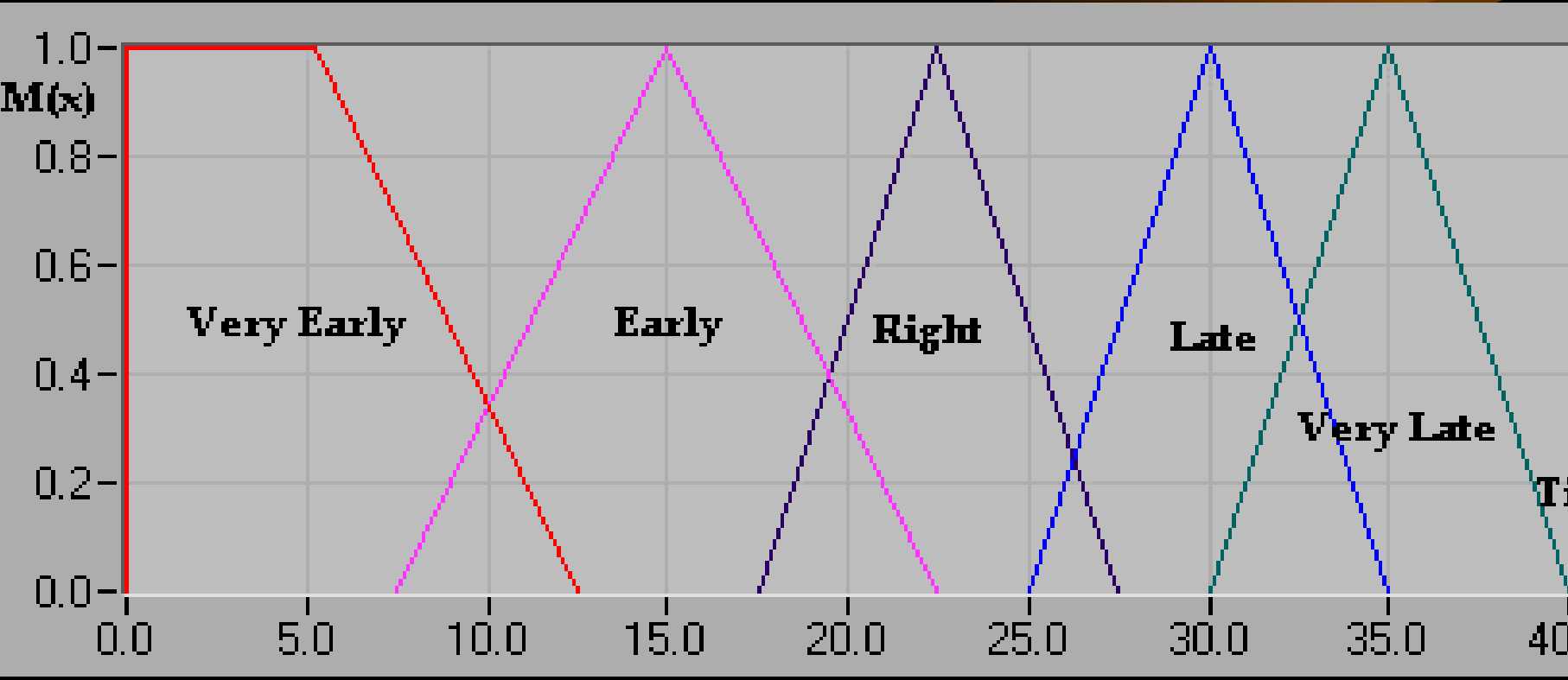
- The Timer fuzzy controller, controlling the timer, has tw
variables: "Dtemp" and "Output".

- They have the same membership functions as those in th
main fuzzy controller. But, the output singleton terms ar
named: "Stop" and "Start".

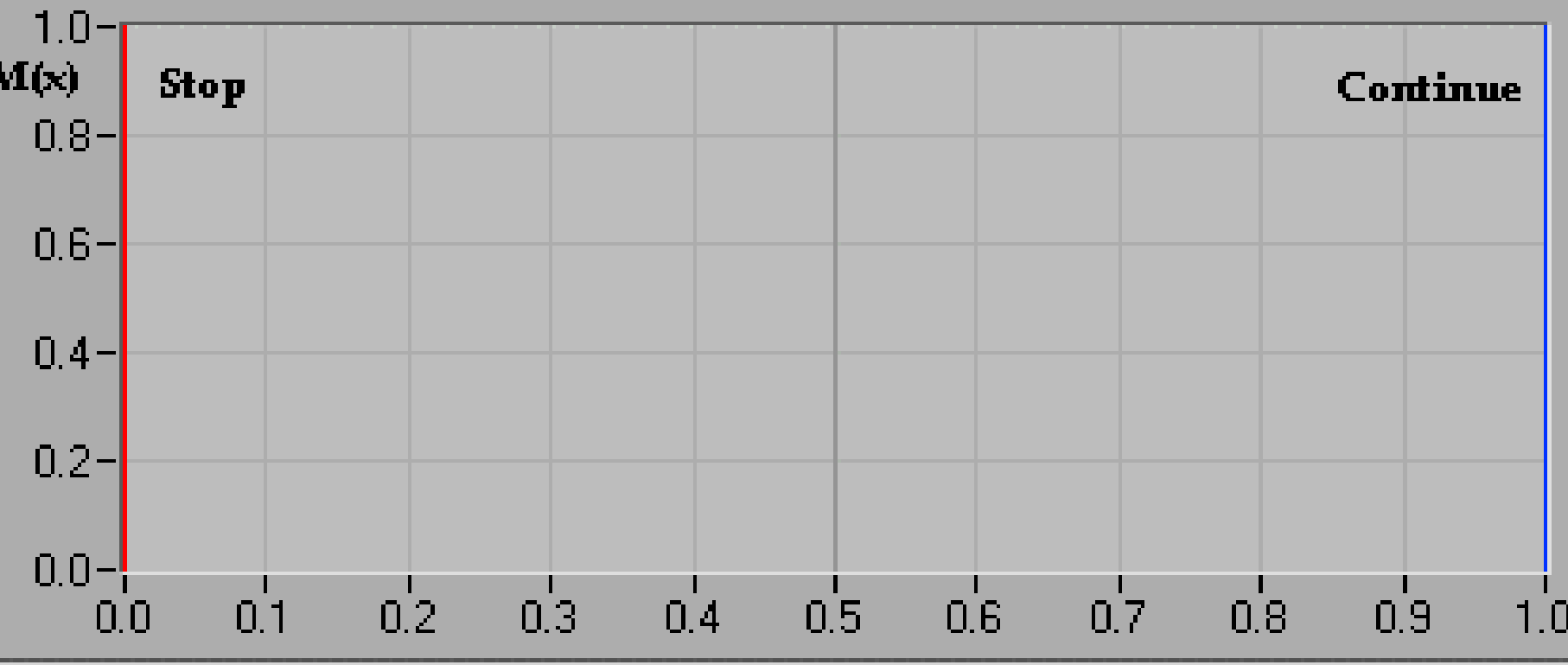
The Fuzzy Inference Model



The Fuzzy Inference Model



The Fuzzy Inference Model



The Fuzzy Inference Model

Inference Rules of the Timer Controller

RULE1: **if** (Dtemp is Very Small) **then** (Output is Start).

RULE2: **if** (Dtemp is Small)**then** (Output is Start).

RULE3: **if** (Dtemp is Medium) **then** (Output is Start).

RULE4: **if** (Dtemp is Large) **then** (Output is Stop).

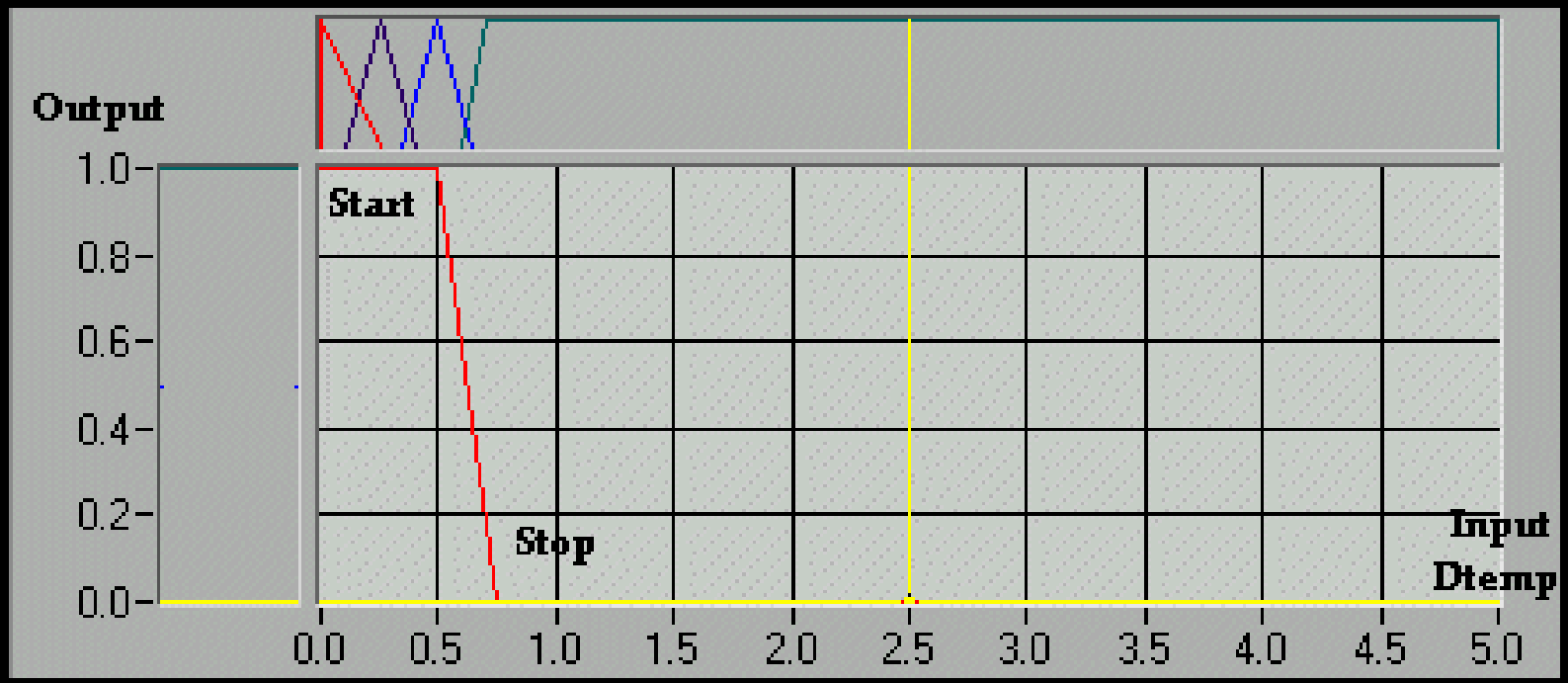
The Fuzzy Inference Model

Inference Rules of the Main Controller

Time / Dtemp	Very Early	Early	Right	Late	Very Late
Very Small	Continue	Stop	Stop	Stop	Stop
Small	Continue	Continue	Stop	Stop	Stop
Medium	Continue	Continue	Continue	Stop	Stop
Large	Continue	Continue	Continue	Continue	Continue

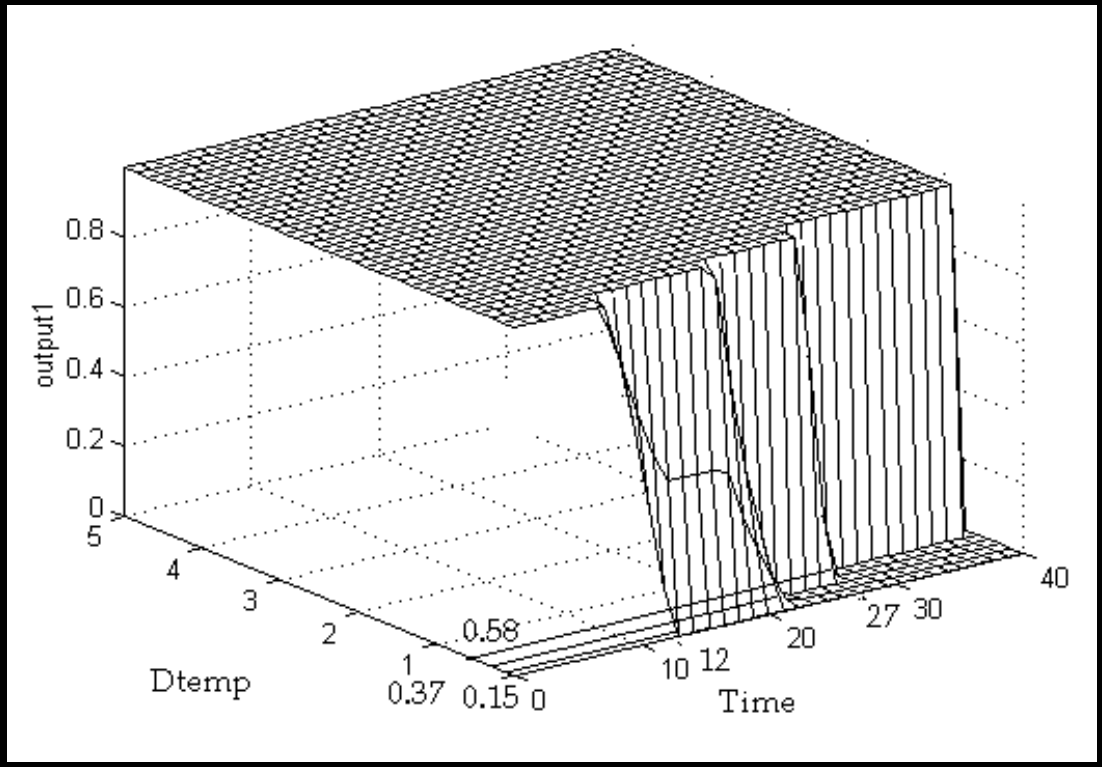
Results and Analysis

Behavior of the output of the Timer fuzzy controller with the change in temperature (Dtemp) Using MOM Defuzzification Method.



Results and Analysis

3D plot of the main controller output versus Dtemp and Time Using MOM Defuzzification Method.



op time estimation at
erent values of Dtemp
ith the saving of the
uzzy over the crisp
controllers

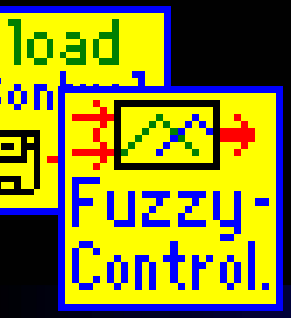
Results and Analysis

Change in Temperature	1st Crisp Controller	2nd Crisp Controller	Fuzzy Controller
0.4 < Dtemp < 0.5	30 min.	30 min.	27 min.
Time Saving in Percent	0 %	0 %	10 %
0.35 < Dtemp < 0.4	30 min.	30 min.	[25 min, 27 min]
Time Saving in Percent	0 %	0 %	[10%, 13%]
0.25 < Dtemp < 0.3	30 min.	25 min	20 min
Time Saving in Percent	0 %	16.7%	33.3%
0 < Dtemp < 0.25	30 min.	20 min	[12 min, 20 min]
Time Saving in Percent	0 %	33%	[33%, 60%]

mparison of crisp and
zy controllers from the
nt of view of software,
development, and
npatibility with human
control.

Results and Analysis

	1st Crisp Controller	2nd Crisp Controller	Fuzzy Controller
Software Complexity	**Simple**	**Complex**	**Simple**
Development	**Complex**	**Complex**	**Easy to develop and tune**
Compatibility with the human operator's behavior	**Covers a single decision**	**Covers multi-decisions but limited**	**Compatible and covers many decisions**



Fuzzy Logic Under LabVIEW

- With the Fuzzy Logic for G Toolkit, you can design a fuzzy logic controller (or expert system) and implement the controller in your G applications.
- Fuzzy membership functions and the controller rule base are defined with the Fuzzy Logic Controller Design VI.
- All parameters of the defined controller controller are saved into a controller data file.

Future Work

•Future research should deal with the tuning and improvement of the fuzzy model to guarantee a real competition and possibly superiority over the human experts in terms of the achievement of the smallest possible temperature and the time needed for the achievement.

•Automating the gas charging using automatic valves could be made by introducing new variables to the fuzzy controller to control the gas amount charged into the refrigerator.