What We Did and Should Have Done In The Past Half Century of Computing

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SEAC 1950

- The first American computer with internal programming capability.
- Built by NBS
- The inspiration for many developments by government, industry, and academia.

Genesis 11:6

- April 1950: Now nothing will be witheld from them which they have conceived to do.

Historical Anecdotes

- I will not attempt a scholarly history.
- Instead, I will draw lessons for the <u>future</u> from historical anecdotes.
- These will be my own personal recollections from 57 years with computers at NBS-NIST.

Video.Google.com
SEAC History

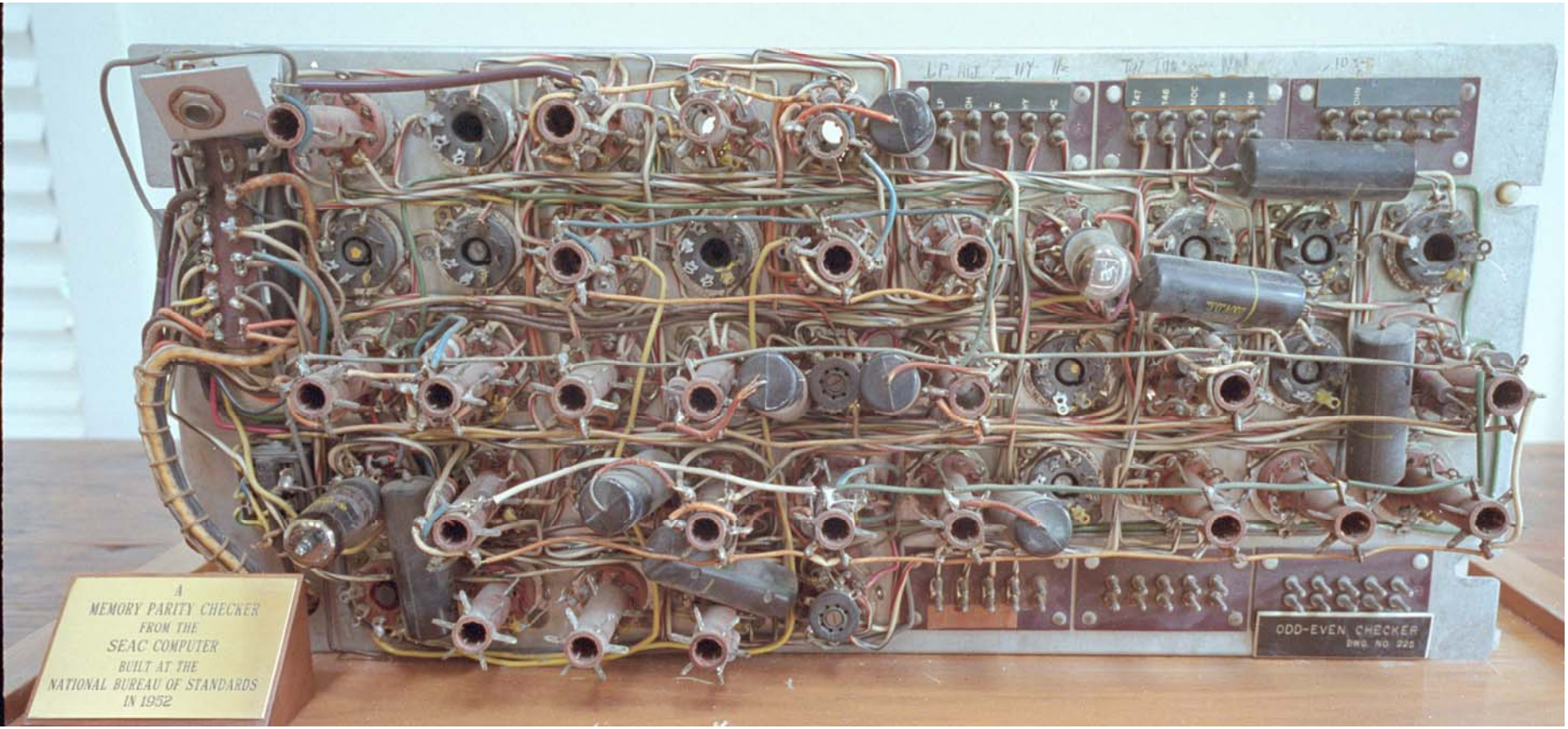
What we should have done

Publicize what we did not know.

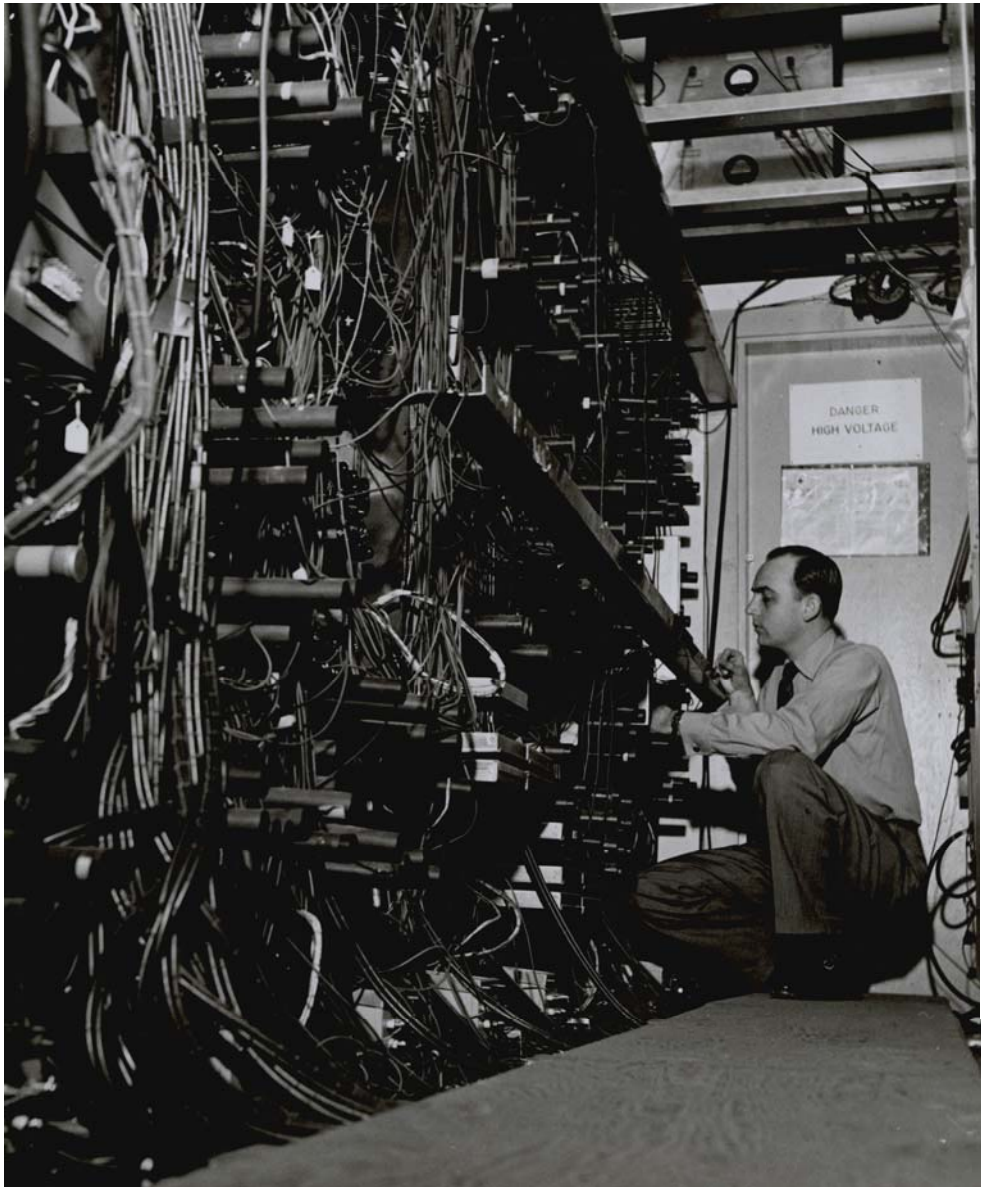
“Flawless Operation”

- SEAC performed productively 24/7 from April 1950.
- Interspersed with productive computation was engineering development of new components and preventive maintenance.
- After 4 years we decided to move SEAC to more spacious quarters.

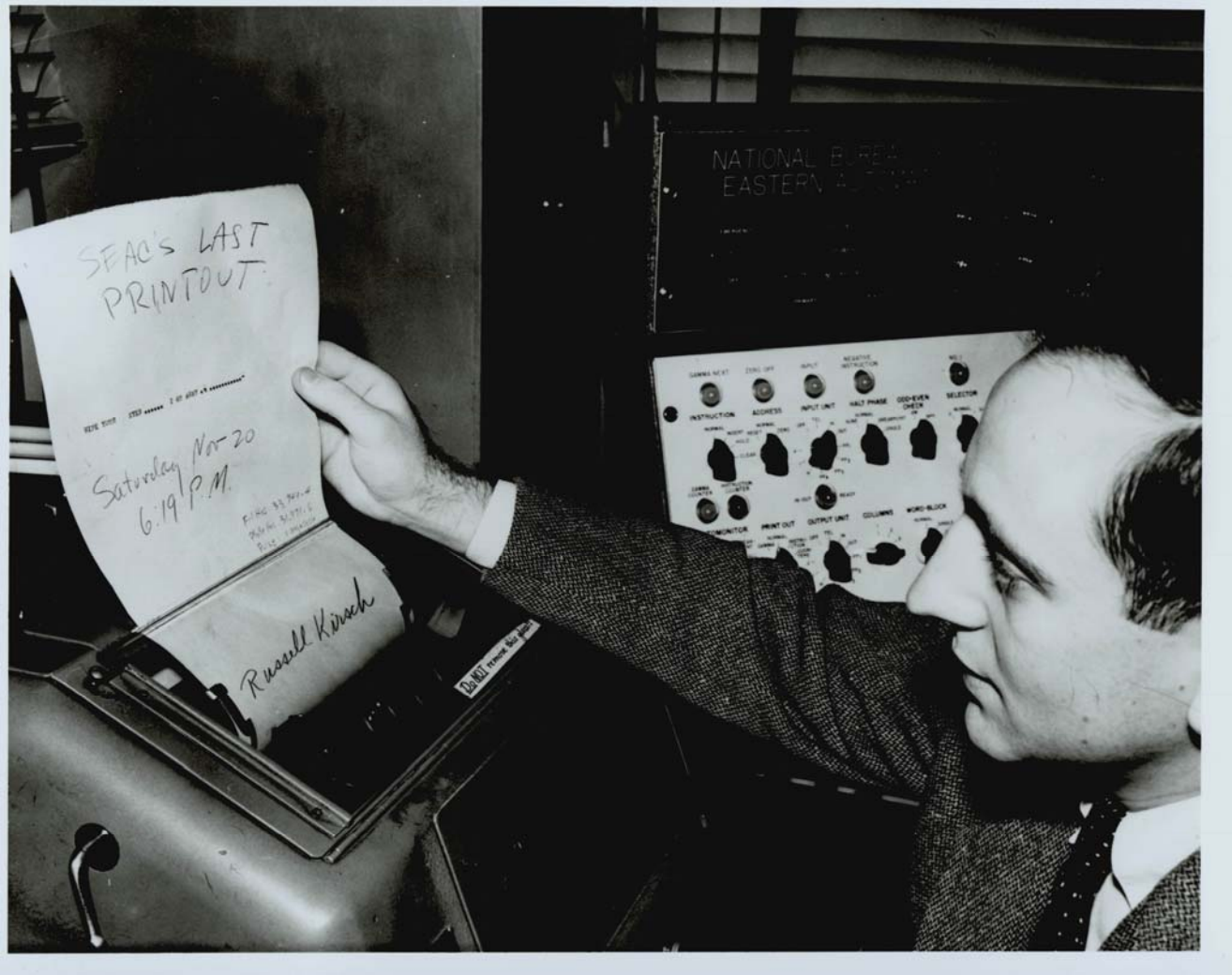
One of over 100 chassis to be disconnected.



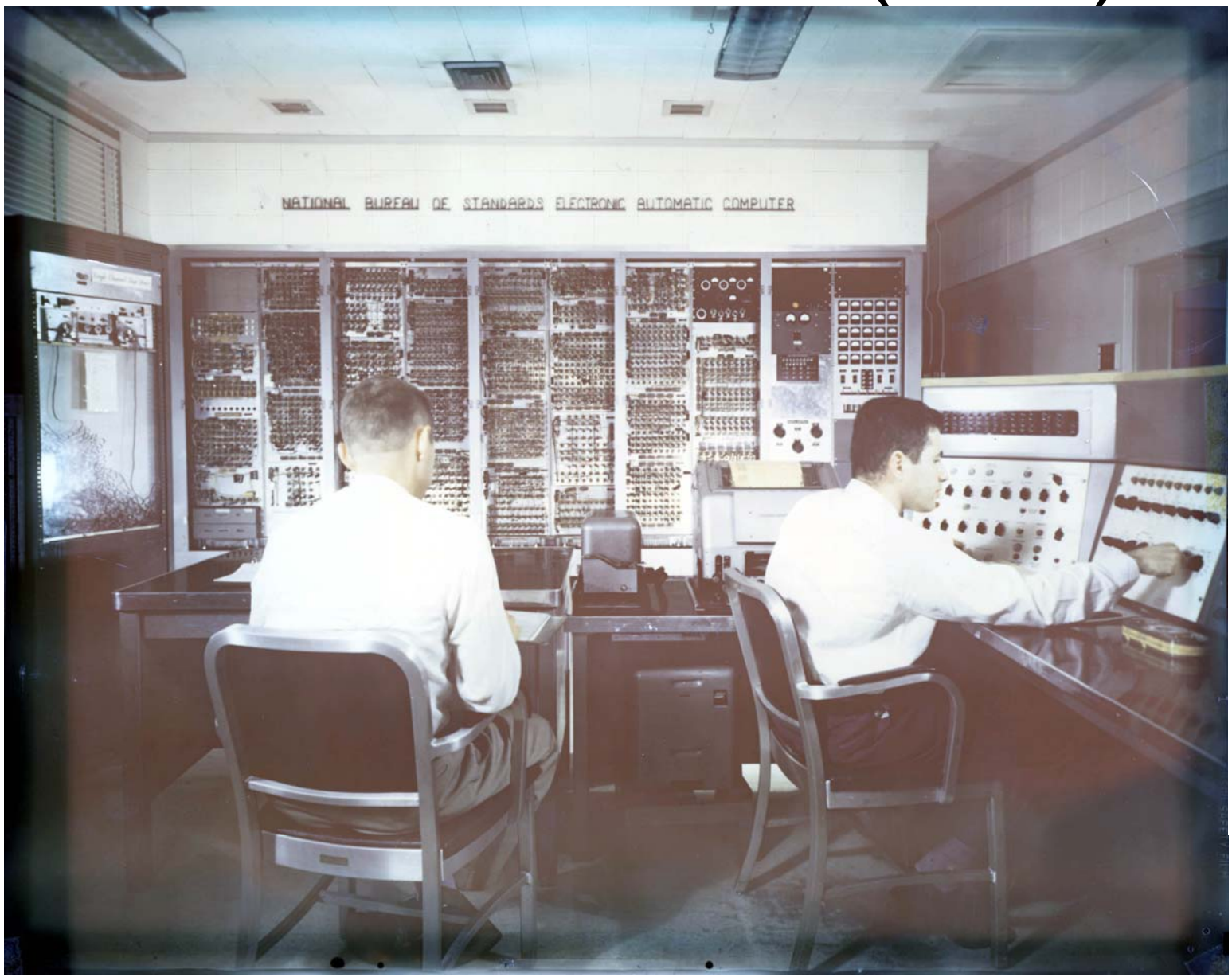
Wiring to reconnect



SEAC's "Last" Printout



SEAC Reassembled (1954)



We all knew the SEAC logic Ruth H. Cahn had even memorized the wiring diagram.

SEAC was broken!

- In reconnecting SEAC I discovered a logical bug that had been present from the beginning.
- Four years of productive computation had never encountered the bug.
- “Knowing” the logic did not assure that we “knew” the operation.
- We should have announced that we did not understand the computer we had designed and built.

We should have been more aware of history

We have been acquiring digital images since 1957

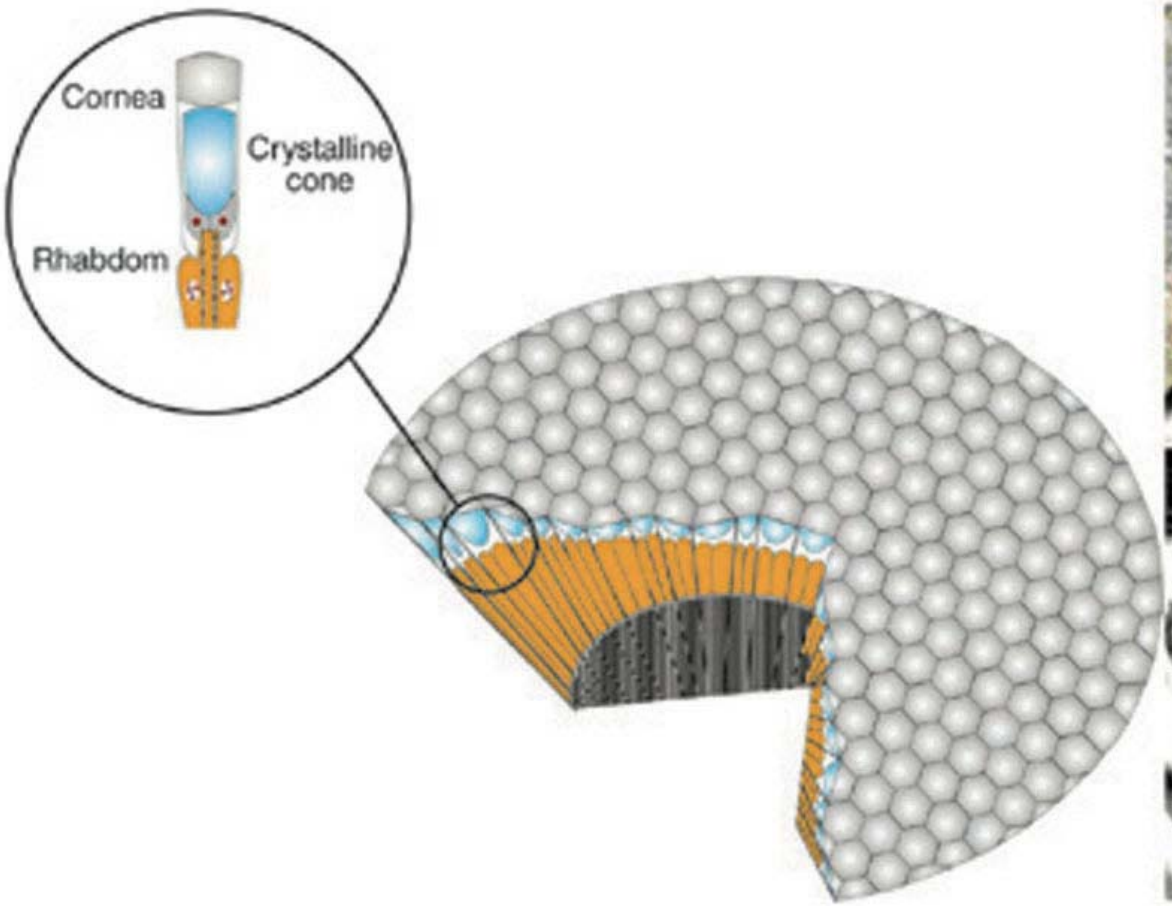
A half century of scans

Ravenna Mosaics

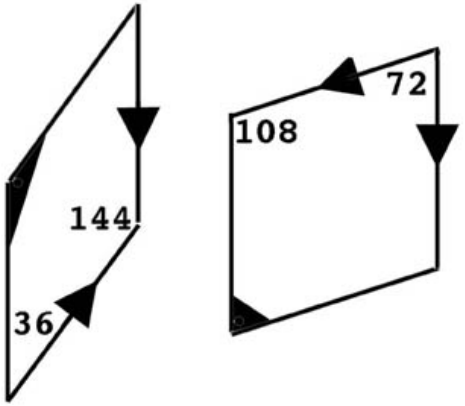
- 1500 years ago, people analyzed images before composing them of discrete tesserae.

Ravenna(500 AD) vs Kirsch (1957 AD)

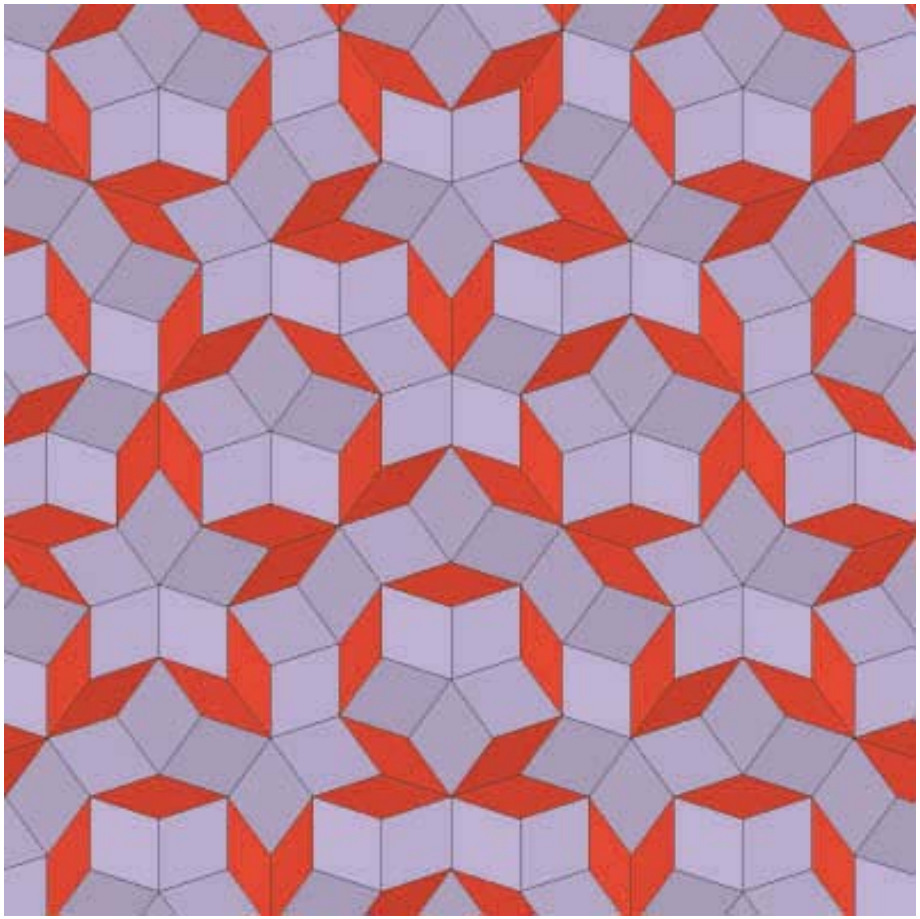
Science 18 Nov 2005
Hex Pixels as in Biology



A better tesselation?

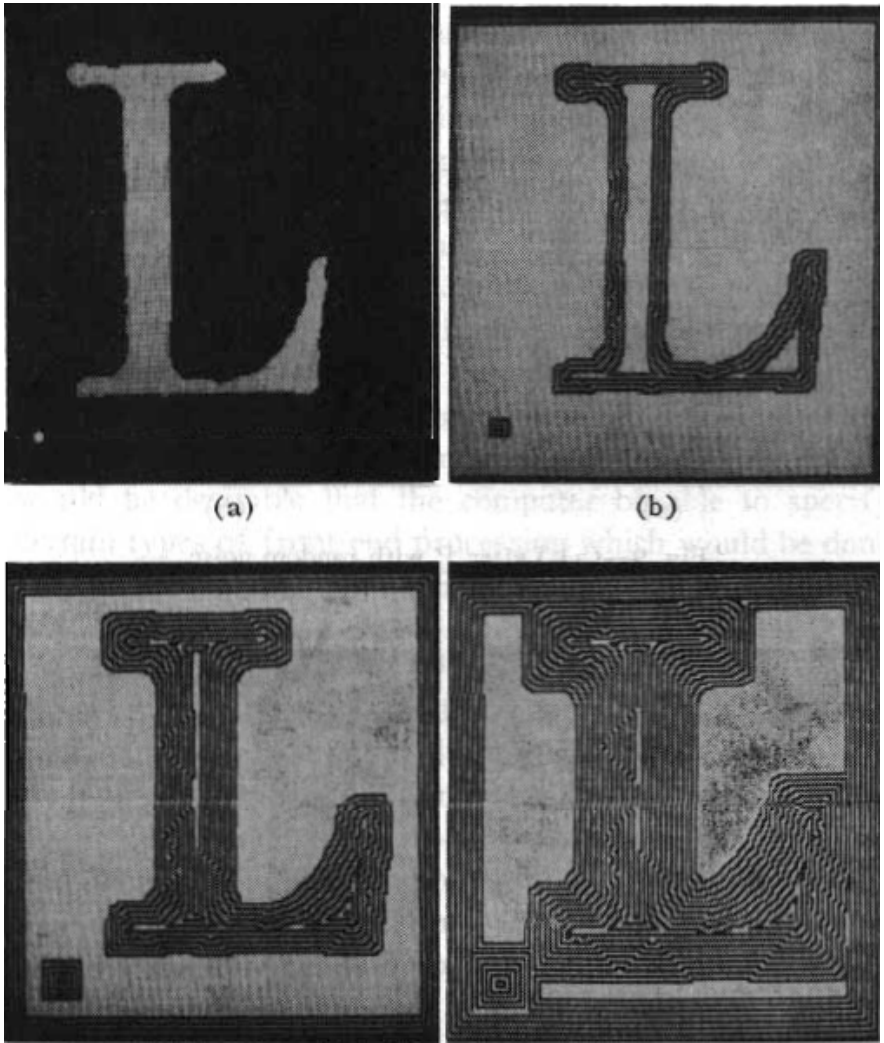


- Penrose tiles can cover the plane in a <u>non-periodic</u> fashion.
- Perhaps this could yield a technology closer to that of Ravenna.



Cellular Automata-”Custering”

- We should have pursued applications in physical modeling in 1957.



Wolfram's "New Kind of Science"

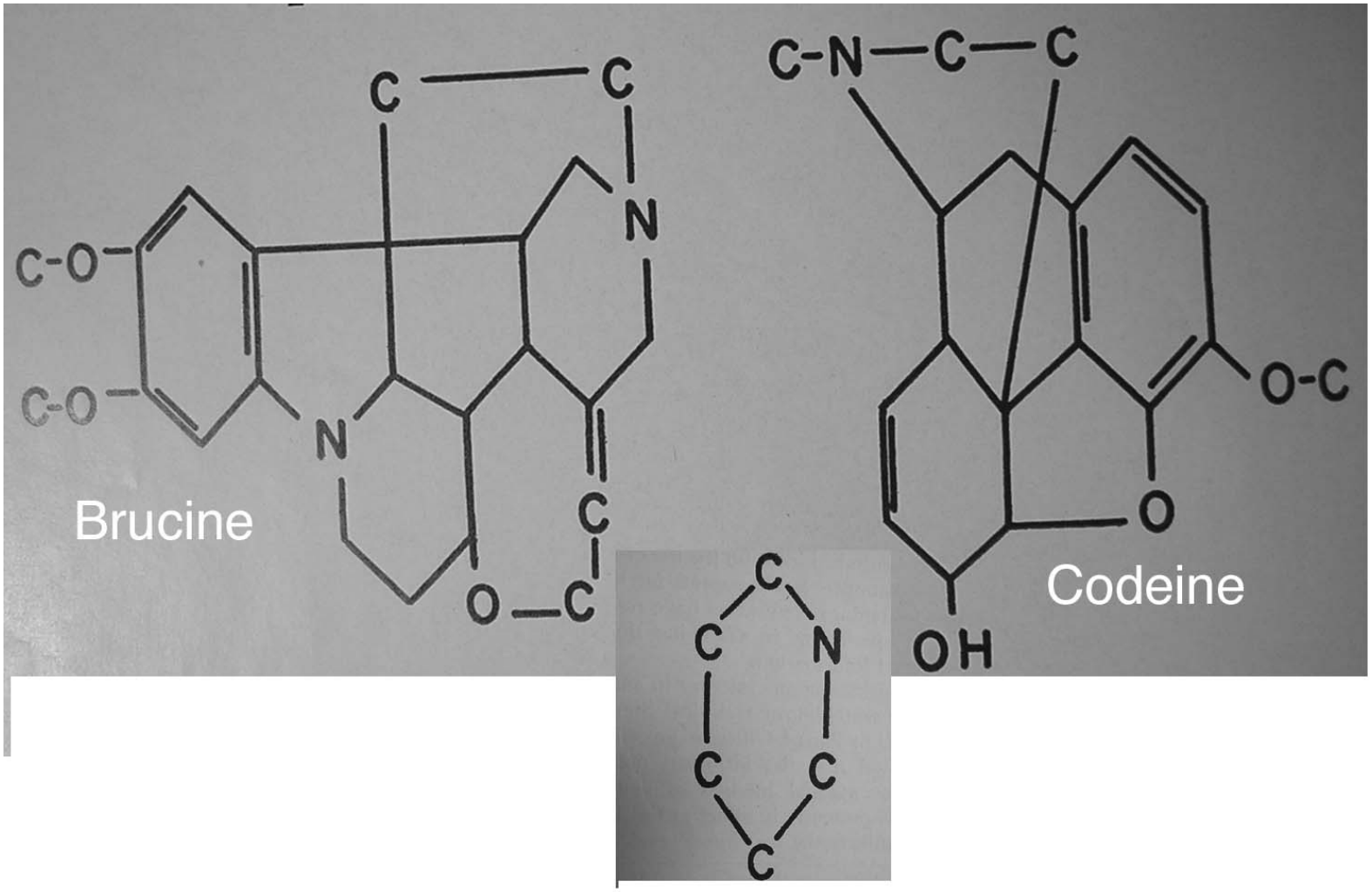
We should have recognized existing visual languages

Examples are in Chemistry
Architecture, and Fine Arts

Example Chemical Info. Searching

- The Patent Office wanted to search the chemical literature.
- They wanted to use chemical nomenclature.
- But we knew that computer topological search for fragments was possible.
- L.C.Ray and R.A.Kirsch, Finding Chemical Records by Digital Computers, Science, 126:3278, pp 814-819 (Oct 25, 1957).

Topology replaced nomenclature



Fragment located in both molecules

This solved the immediate problem

- But it ignored the larger problem:
- Describing visual languages

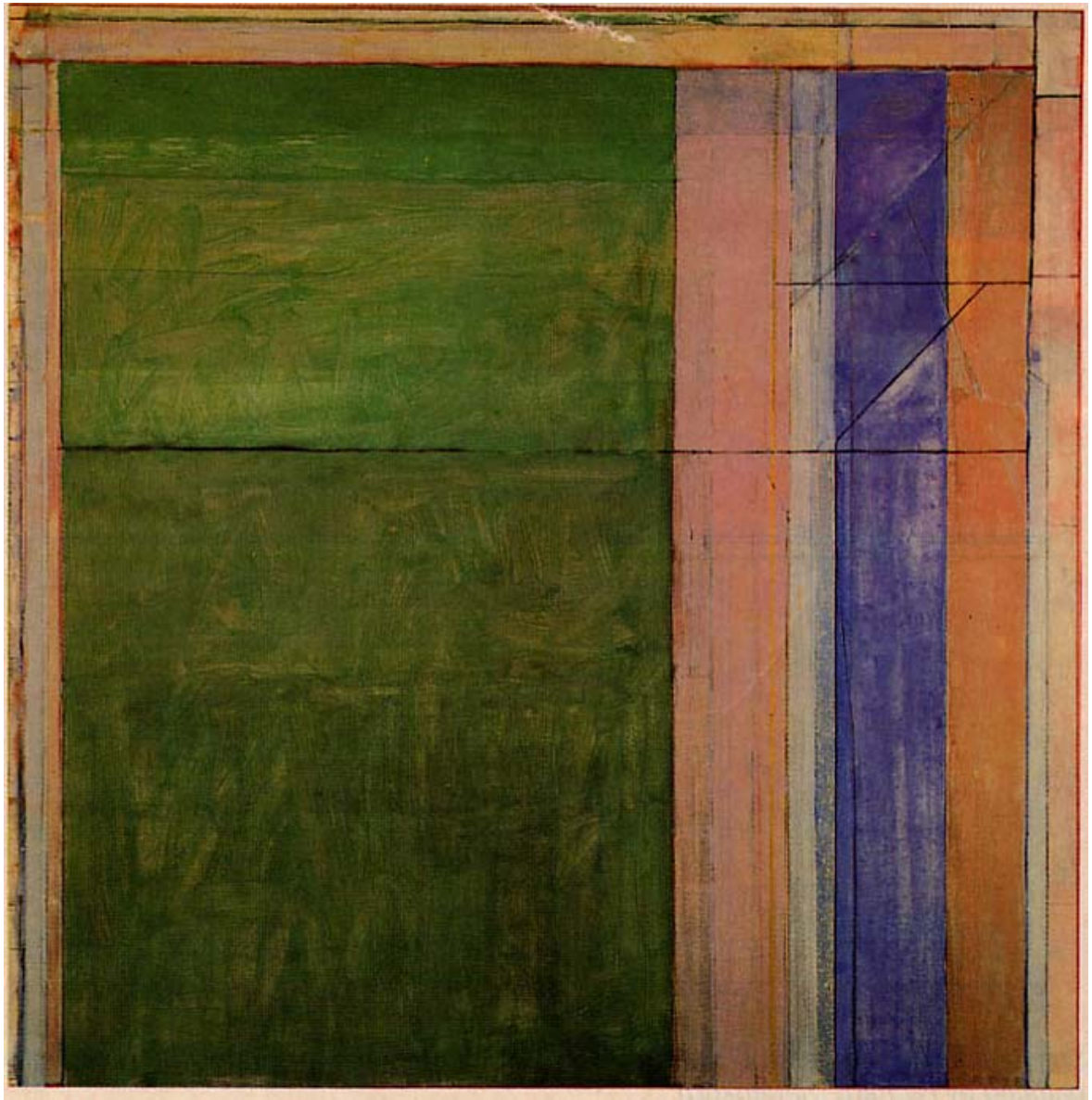
Picture Grammars

- A decade later we invented a mechanism for describing visual languages.
- It was used by others in Architecture
- We applied it to the fine arts.

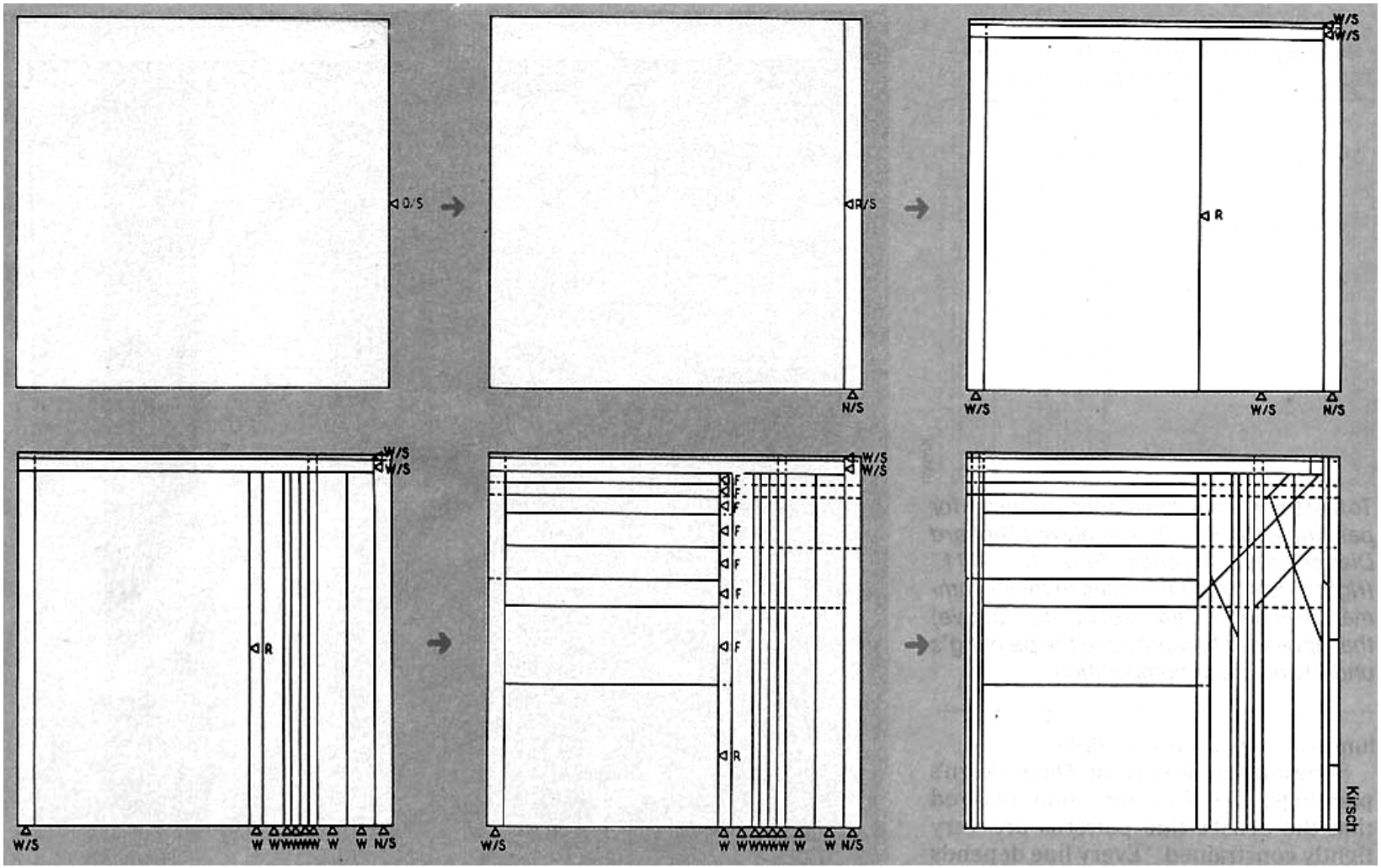
Example: Fine Arts

- The picture grammars we invented in 1964 can be used to analyze style in art.
- We wrote a grammar for the style of the painter Richard Diebenkorn.

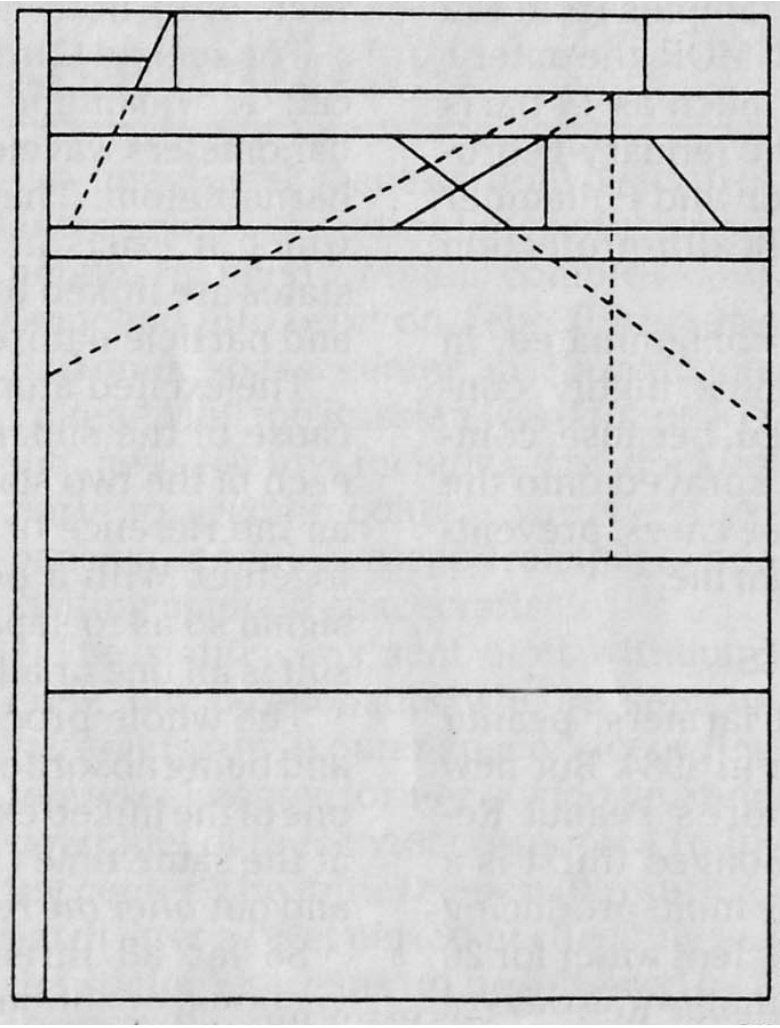
Diebenkorn’s Ocean Park 111 at the Smithsonian Hirshhorn Museum



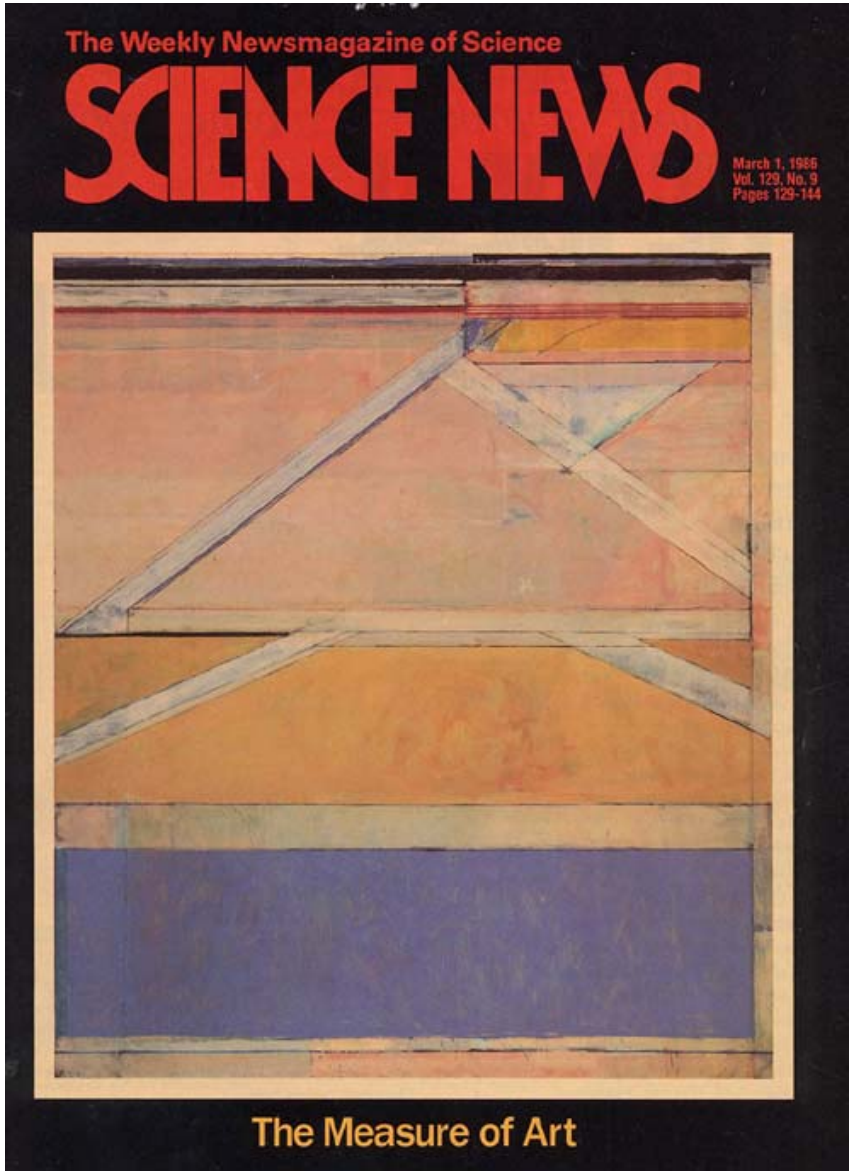
Generation of O.P. 111 from the grammar

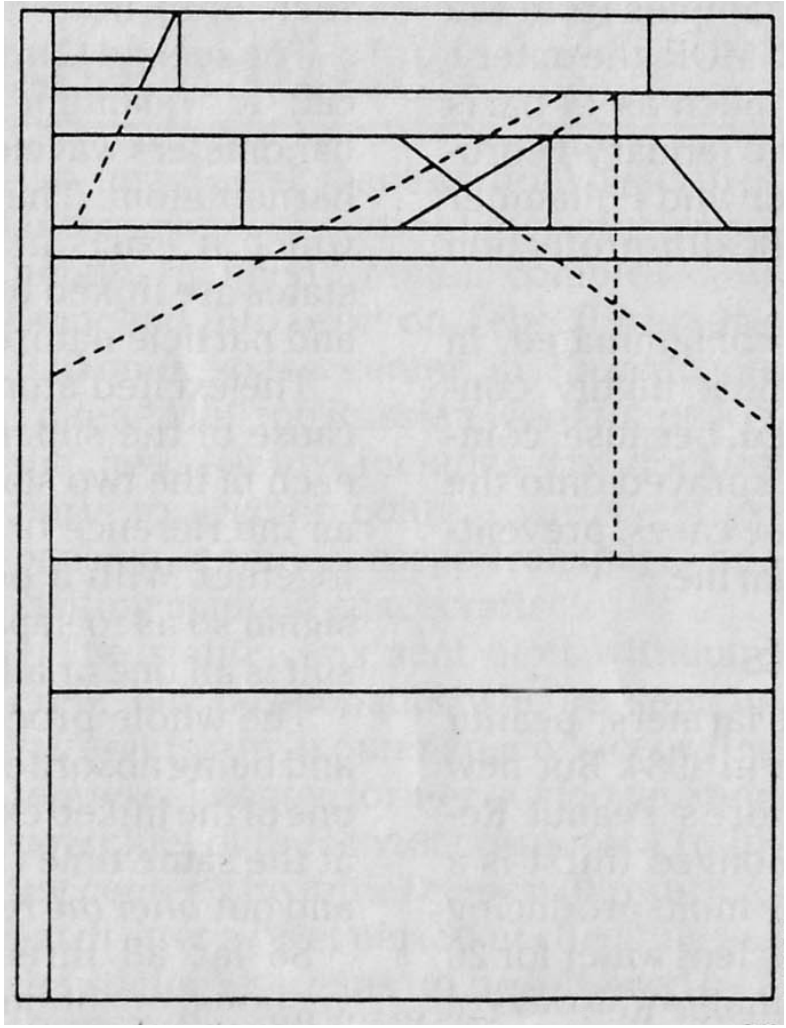


A “new” O.P. generated by our grammar



The “new” painting already exists!





We should have helped stamp out certain creativity

- We encouraged the use of computer graphics to make new art.
- We should have emphasized the understanding of the past 36,000 years of existing art.

- A lot of existing art which we understand we should explain to computers.

Visual languages today

- Mostly, people design new visual (programming) languages.
- Annual Diagram Conferences investigate language design.
- But language description is still ignored.

We should have made computers understand textual language

Scientific Info. Retrieval

- In 1957 we were competing with the USSR not only in space (Sputnik) but in computer access to scientific information.
- Many ideas were proposed but the majority used word occurrences to retrieve information.

1958 NAS Int'l Conf. Scientific Information

- Z.Harris (Linguistics), Y. Bar-Hillel (Logic), C.E.Shannon (Info. Theory), Marvin Minsky(A.I.), others and myself argued for fundamental research in what we now are doing in Ontologies.
- Had the Nat. Acad. Of Sci. recognized the merit of these arguments we would be a half century closer to the Semantic Web.
- So today we have Google instead.

Complexity of Human Vision

We should have recognized that people have complex built-in capabilities that computers must imitate to do pattern recognition

Complexity of human vision

- Last night I saw upon the stair
- a little man who wasn’t there.
- He wasn’t there again today.
- Oh how I wish he’d go away.

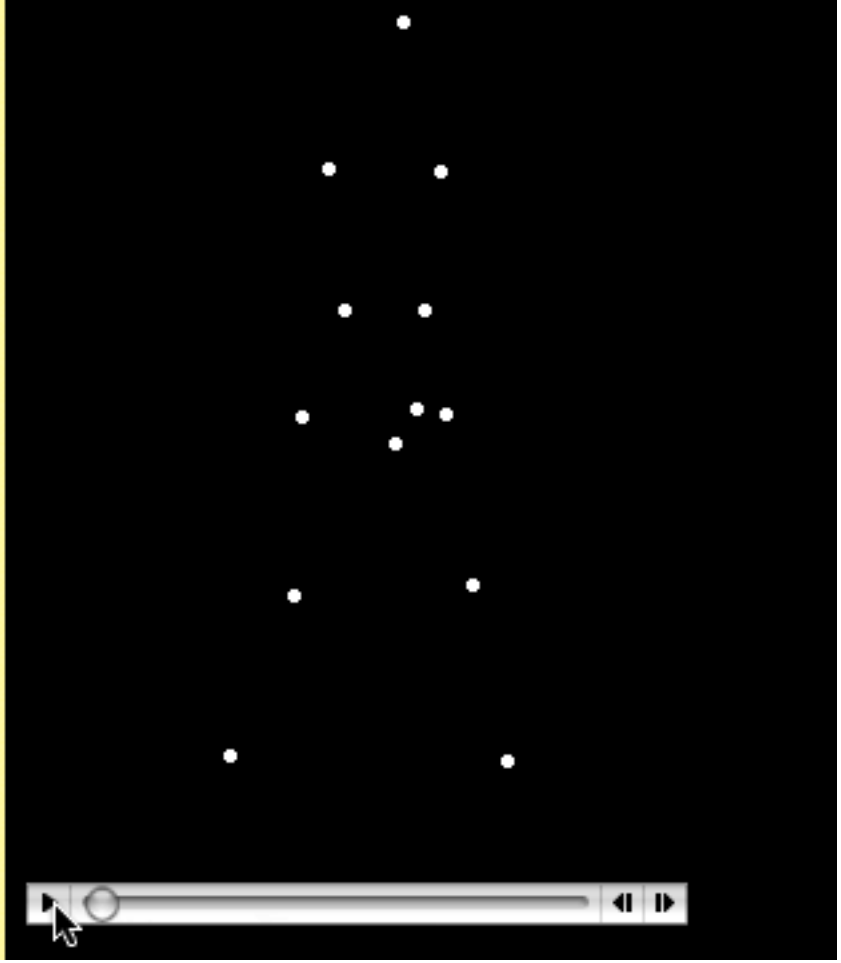
The Human Observer…

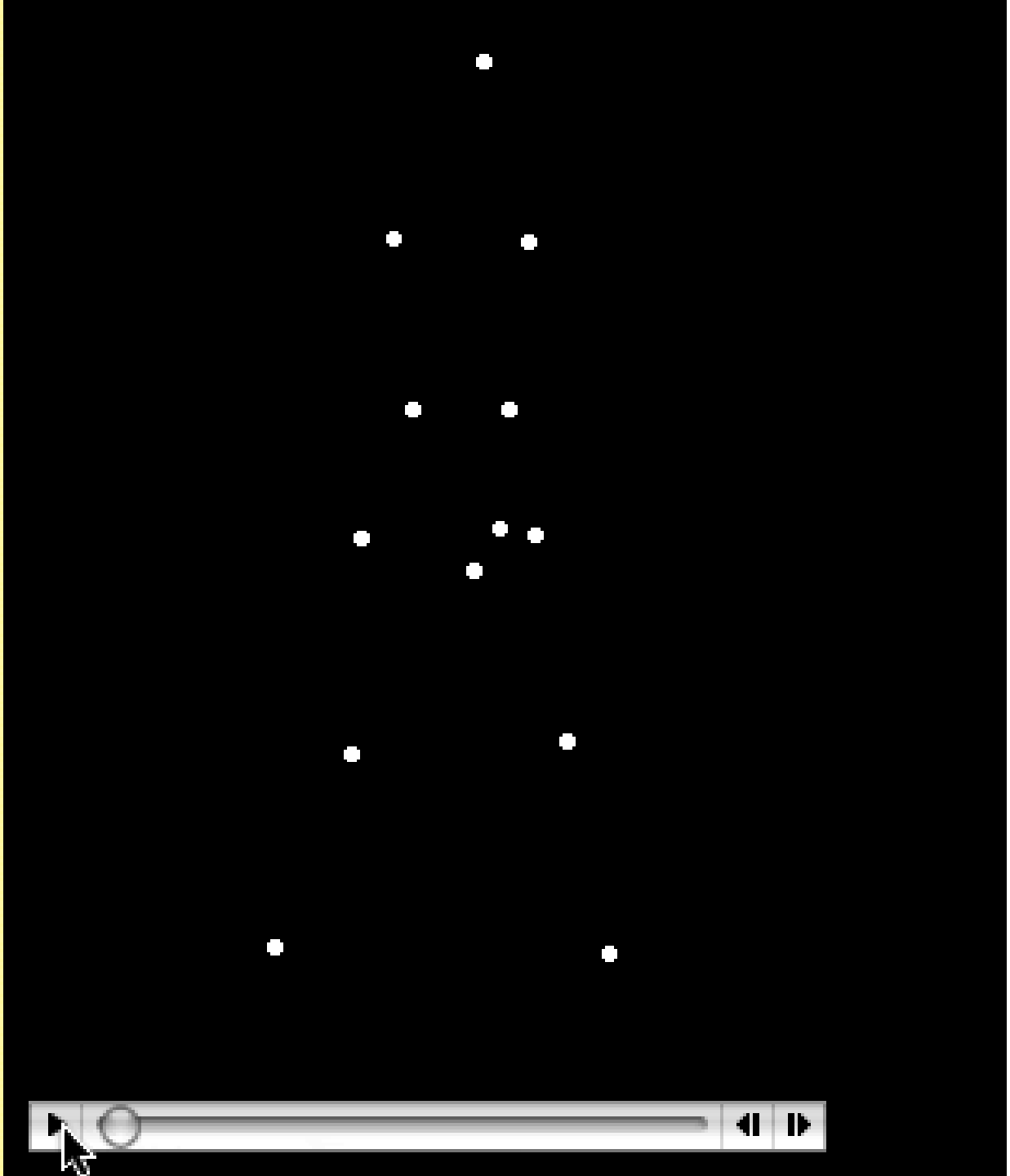
- …invokes learned response. This is how we “read” drawings, diagrams, photos, and even physical objects.
- …invokes ontogenetic properties. These are largely mysterious and resistant to computer simulation. Examples: Human Movement, Faces.

Human Recognition Ability

- We are endowed, at birth, with the ability to recognize certain kinds of motions as well as certain objects, notably human faces.
- We must invoke biological knowledge if we expect computers to be able to imitate such behavior.

13 moving points of light





Expert Systems

- We thought that interviewing experts about how they behave would enable us to duplicate their behavior with computers.
- Lawrence Olivier in Othello.

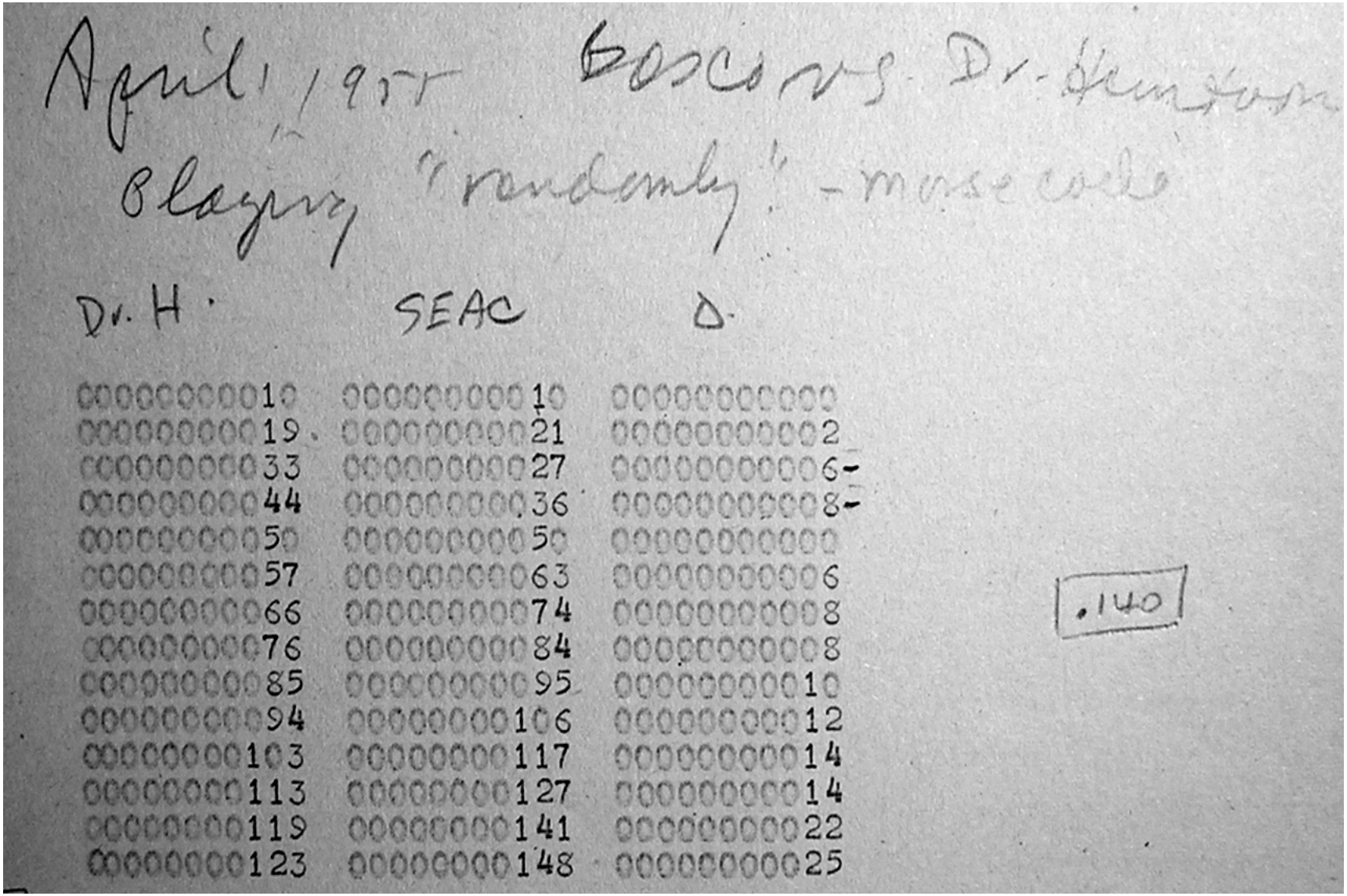
Pursuing mathematical applications

- I discovered some interesting mathematics when I wrote the first Artificial Intelligence Learning Program.
- Coin Matching
  First Computer Game- 1954
- I should have further explored this mathematics.

The program used history to make predictions.

- It used what followed the most recent two moves of its opponent to predict the opponent’s next move.

Easily defeated human opponents



Consistently lost to a suitable programmed sequence

Generated from polynomials irreducible over finite Galois fields: “Shift Register Sequences”

0 0 0 1 0 1 1 1- 0 0 0 1 0 1 1 1-

0 5 6

1 3 4

2 7

All subsequences occur once per period.

Wide variety of applications

These sequences were later used by others for:

- Error correcting codes
- Radar ranging
- Analog shaft encoders
- Magnetic drum addressing

I have pursued other applications in

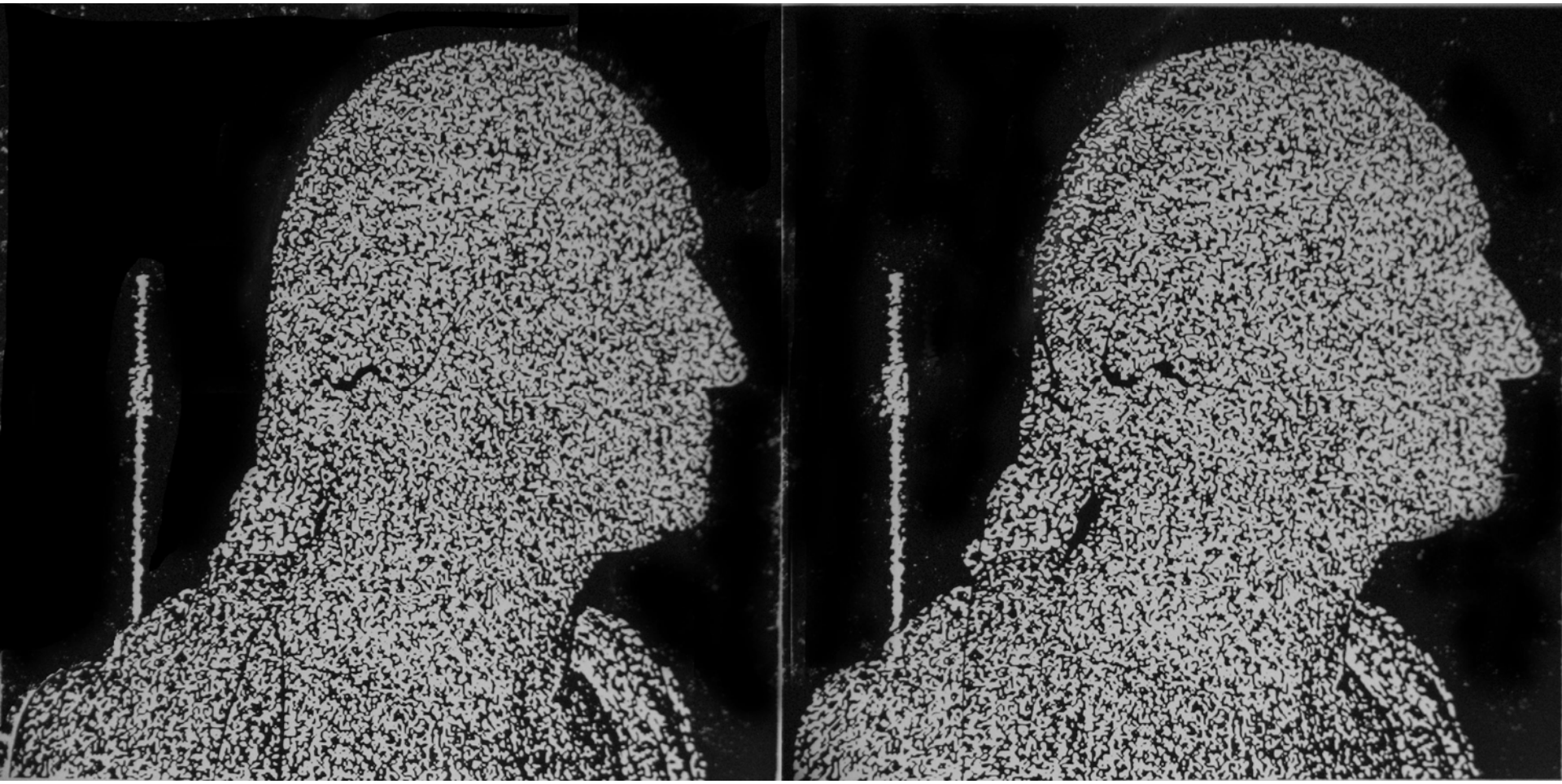
- Stereophotogrammetry
- Color Imaging
- Music

Structured Illumination for 3D Reconstruction From Stereo Pairs Of Images

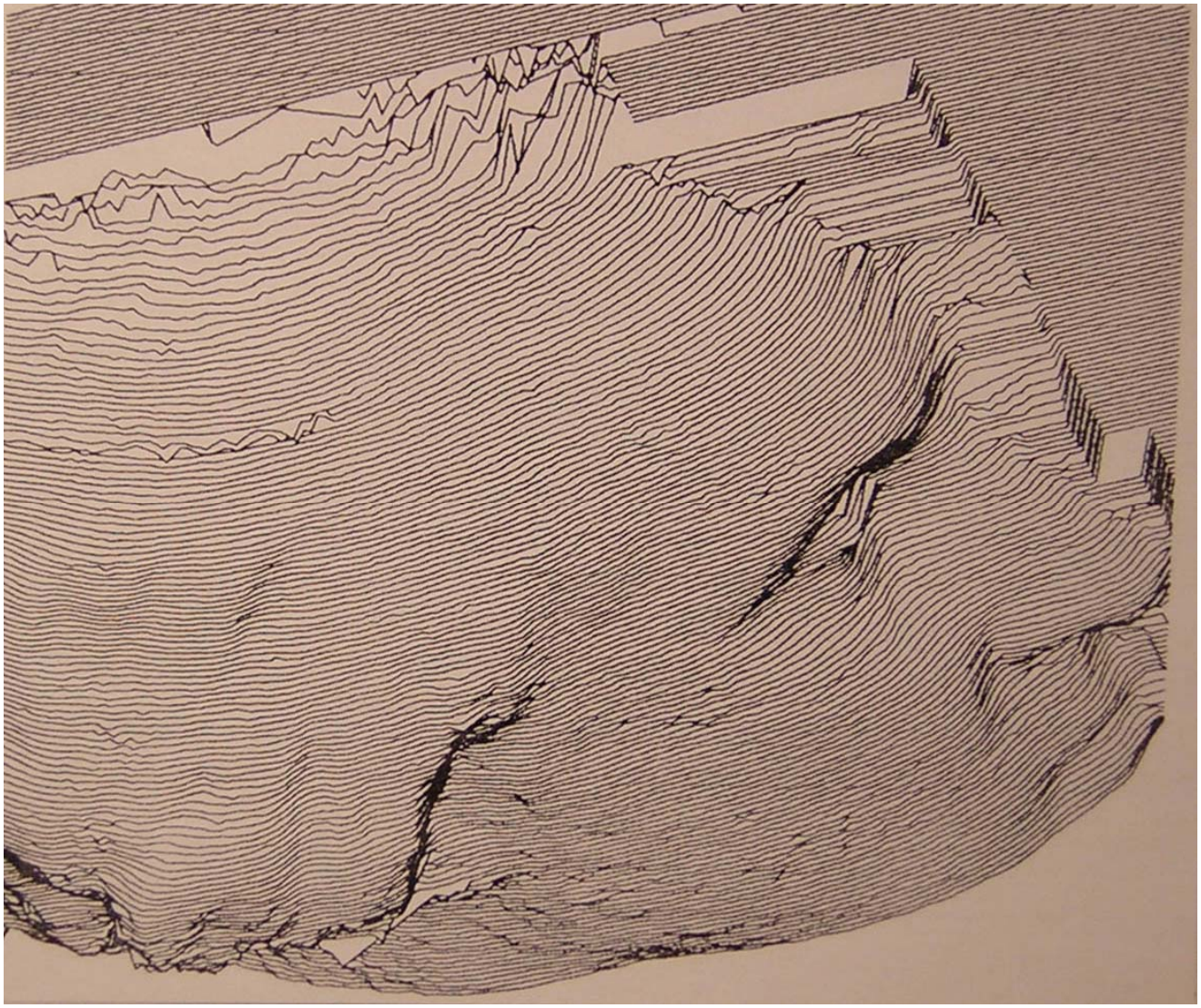
- I generated a special pattern from Shift Register Sequences.
- This enables unique location of each illuminated pixel in a stereo pair.
- From such a stereo pair, explicit 3D information can be extracted.

Houdon Sculpture Lacking Texture For Matching Pixels

Illuminated with SR Sequence



Stereo Reconstruction



Images and Sound

- We can use the fact that all subsequences occur in one period of a shift register sequence to make interesting pictures and music.

All Colors

- In one sequence all of Red, Green, and Blue can be created. The combination appears gray until it is expanded to show all the component colors.

QuickTime™ and a
Animation decompressor
are needed to see this picture.

Many notes from the key of C

A shift register sequence with 7 symbols can be used to produce all sequences of a,b,c,d,e,f,g notes

Final Song

- Pioneers
- The pioneers are of two kinds
- depending on what's in their minds.
- The first kind concentrates on how
- to change the present here and now
- and thereby fails to realize
- what's seen by those with future eyes.
- The second knows what soon will be
- but also thereby fails to see
- the way to make intial change
- to guarantee the distant range.
- I once was mostly of type one
- and thus I got the first jobs done.
- But now I'm mostly of type two
- which leaves the present tasks to you.