

This slide has been intentionally left blank.

# Turing test

- ▶ The original Turing Test requires three terminals, each of which is physically separated from the other two.
- ▶ One terminal is operated by a computer, while the other two are operated by humans.
- ▶ One of the humans functions as the questioner, while the second human and the computer function as respondents.
- ▶ The questioner interrogates the respondents within a specific subject area, using a specified format and context.
- ▶ After a preset length of time or number of questions, the questioner is then asked to decide which respondent was human and which was a computer.

# Turing test

Q. Please write me a sonnet on the subject of the Forth Bridge [a bridge over the Firth of Forth, in Scotland].

A. Count me out on this one. I never could write poetry.

Q. Add 34957 to 70764.

A. (Pause about 30 seconds and then give as answer) 105621.

Q. Do you play chess?

A. Yes.

Q. I have K at my K1, and no other pieces. You have only K at K6 and R at R1. It is your move. What do you play?

A. (After a pause of 15 seconds) R-R8 mate.

# Turing test

Q. Please write me a sonnet on the subject of the Forth Bridge [a bridge over the Firth of Forth, in Scotland].

A. Count me out on this one. I never could write poetry.

Q. Add 34957 to 70764.

A. (Pause about 30 seconds and then give as answer) 105621.

Q. Do you play chess?

A. Yes.

Q. I have K at my K1, and no other pieces. You have only K at K6 and R at R1. It is your move. What do you play?

A. (After a pause of 15 seconds) R-R8 mate.

- 
- (1) a run-time error on the hardware level (i.e., an irreproducible fluke);
  - (2) an unintentional hardware (or programming) (reproducibly) causes arithmetical mistakes;
  - (3) a ploy deliberately inserted by the machine's programmer (or builder) to introduce occasional arithmetical mistakes, so as to trick interrogators;
  - (4) an unanticipated epiphenomenon: the program has a hard time thinking abstractly, and simply made "an honest mistake", which it might not make the next time around;
  - (5) a joke on the part of the machine itself, deliberately teasing its interrogator.

# What is AI

1979 version:

## **Theorem (Tesler)**

*AI is whatever hasn't been done yet.*

# What is AI

1979 version:

## **Theorem (Tesler)**

*AI is whatever hasn't been done yet.*

2019 version:

## **Theorem (Brazdil)**

*AI is whatever has been done so far.*

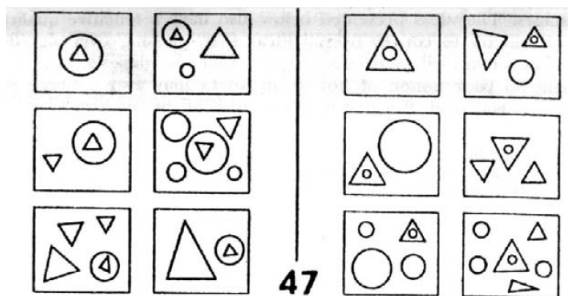
... and will be in the future.

# Questions ...

Question: Will we understand what intelligence and consciousness and free will and "I" are when we have made an intelligent program?

Speculation: Sort of-it all depends on what you mean by "understand". On a gut level, each of us probably has about as good an understanding as is possible of those things, to start with. It is like listening to music. Do you really understand Bach because you have taken him apart? Or did you understand it that time you felt the exhilaration in every nerve in your body? Do we understand how the speed of light is constant in every inertial reference frame? We can do the math, but no one in the world has a truly relativistic intuition. And probably no one will ever understand the mysteries of intelligence and consciousness in an intuitive way. Each of us can understand *people*, and that is probably about as close as you can come.

# Bongard's problems



- ▶ Preprocessing, stage 1: line segment, curve, horizontal, vertical, black, white, big, small, pointy, round ...
- ▶ Preprocessing, stage 2: triangle, circle, square, indentation, protrusion, right angle, vertex, cusp, arrow ...

## Higher level descriptions ...

three shapes

*or*

three white shapes

*or*

a circle on the right

*or*

two triangles and a circle

*or*

two upwards-pointing triangles

*or*

one large shape and two small shapes

*or*

one curved shape and two straight-edged shapes

*or*

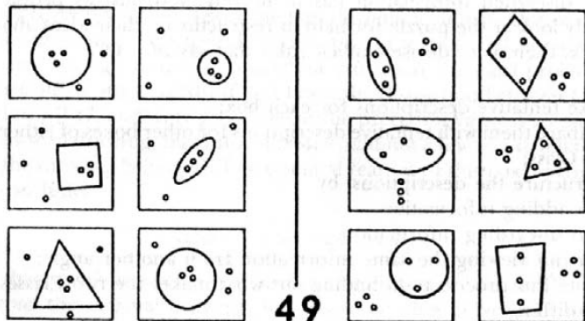
a circle with the same kind of shape on the inside and outside.

make tentative descriptions for each box;  
compare them with tentative descriptions for other boxes of either Class;  
restructure the descriptions, by

- (i) adding information,
- (ii) discarding information,

or (iii) viewing the same information from another angle; iterate this process until finding out what makes the two Classes differ.

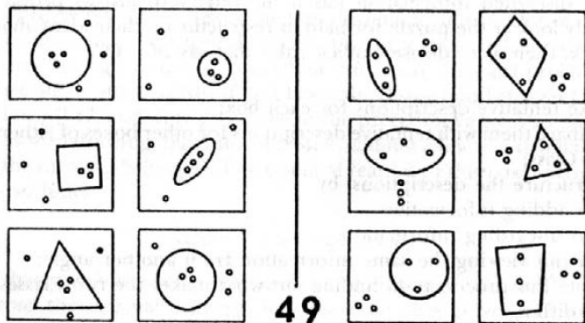
# Templates, sameness, concepts



Template 1:

large closed curve:-----  
small o's:-----

# Templates, sameness, concepts



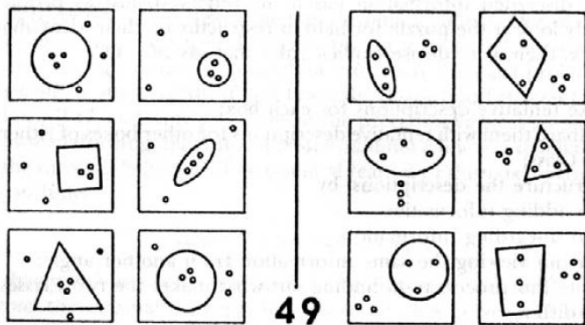
Template 2:

large closed curve: ----

little o's in interior: ----

little o's in exterior: ----

# Templates, sameness, concepts



Template 3:

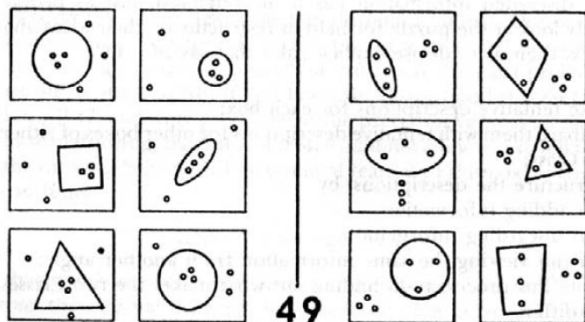
I-A

large closed curve: *circle*  
little o's in interior: *three*  
little o's in exterior: *three*

II-A

large closed curve: *cigar*  
little o's in interior: *three*  
little o's in exterior: *three*

# Templates, sameness, concepts



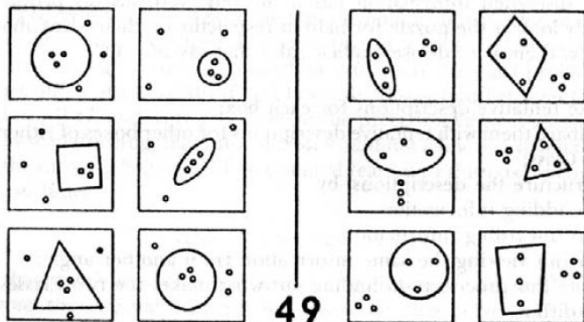
Template 4:

large closed curve:----

three little o's in interior: ----

three little o's in exterior:----

# Templates, sameness, concepts



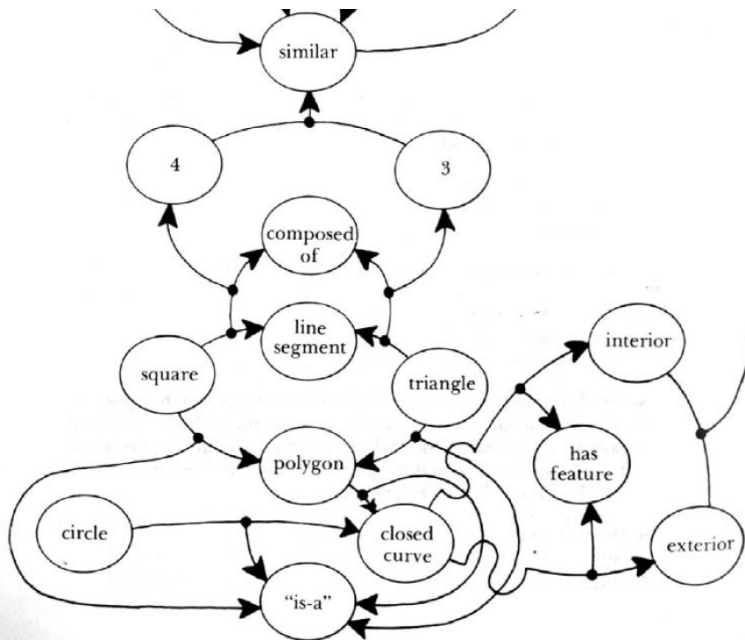
Template 5: For II-E

large closed curve: *circle*

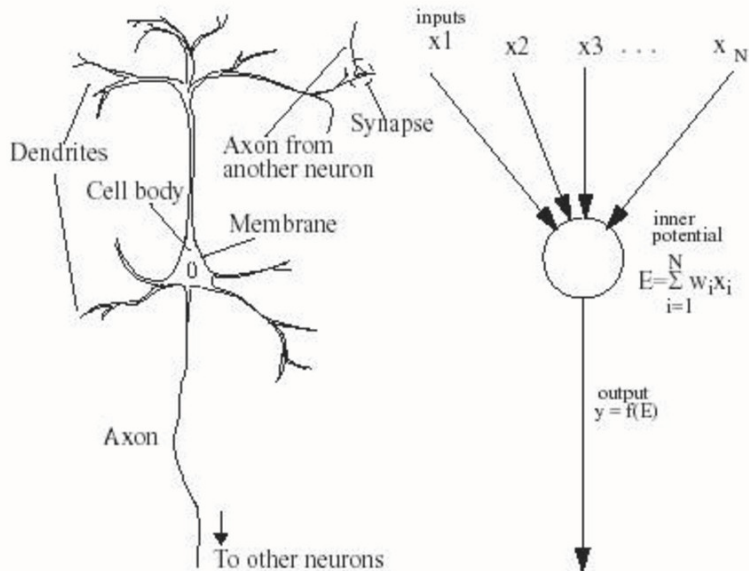
three little o's in interior: *equilateral triangle*

three little o's in exterior: *equilateral triangle*

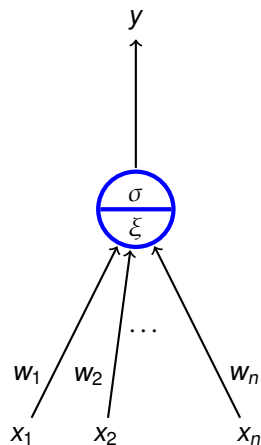
# Concept network



# Biological and Mathematical neurons



# Formal neuron (without bias)



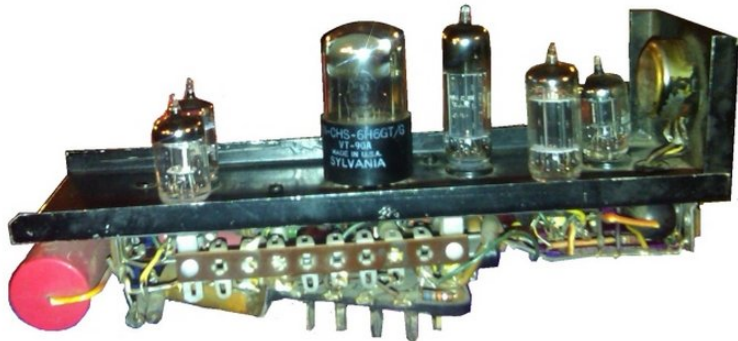
- ▶  $x_1, \dots, x_n \in \mathbb{R}$  are **inputs**
- ▶  $w_1, \dots, w_n \in \mathbb{R}$  are **weights**
- ▶  $\xi$  is an **inner potential**;  
almost always  $\xi = \sum_{i=1}^n w_i x_i$
- ▶  $y$  is an **output** given by  $y = \sigma(\xi)$   
where  $\sigma$  is an **activation function**;  
e.g. a *unit step function*

$$\sigma(\xi) = \begin{cases} 1 & \xi \geq h; \\ 0 & \xi < h. \end{cases}$$

where  $h \in \mathbb{R}$  is a *threshold*.

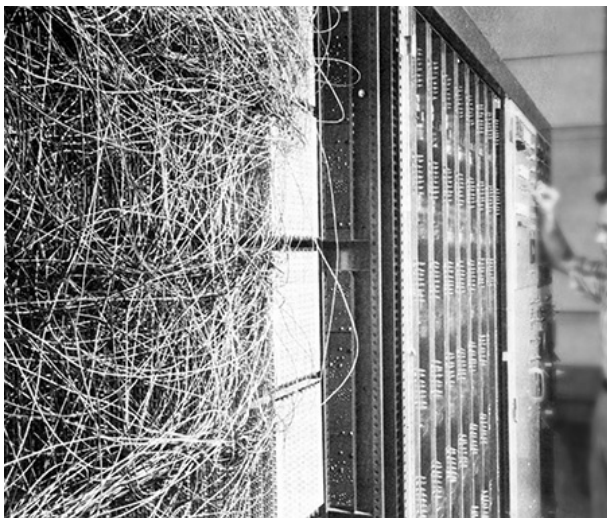
# History of neurocomputers

- ▶ 1951: SNARC (Minski et al)
  - ▶ the first implementation of neural network
  - ▶ a rat strives to exit a maze
  - ▶ 40 artificial neurons (300 vacuum tubes, engines, etc.)

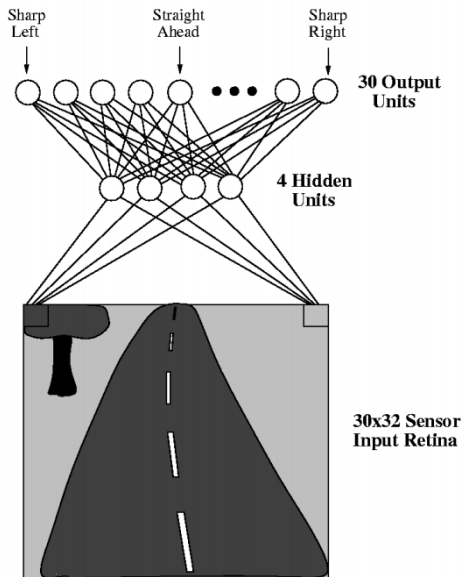


# History of neurocomputers

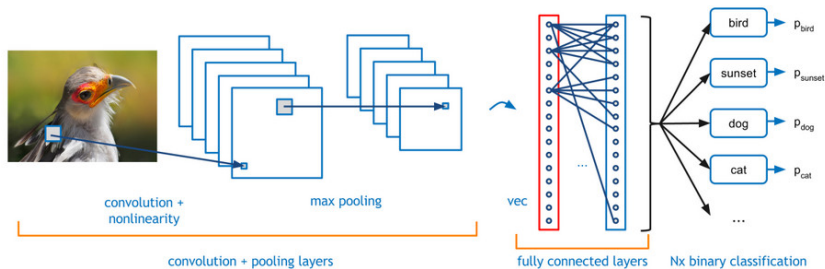
- ▶ 1957: Mark I Perceptron (Rosenblatt et al) - the first successful network for image recognition
- ▶ Recognized digits 0 - 9.



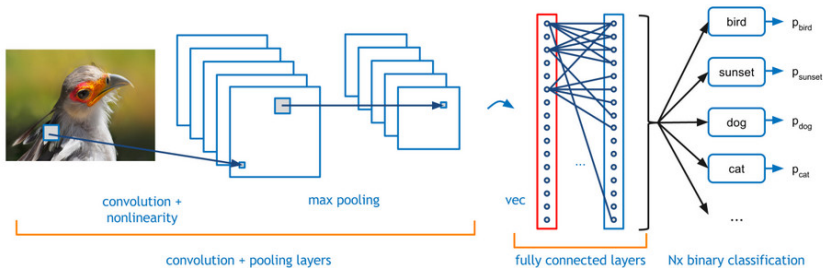
# ALVINN (in 1989!)



# Image classification network



# Image classification network



GOOGLE DATACENTER

1,000 CPU Servers  
2,000 CPUs • 16,000 cores

**600 kWatts**  
**\$5,000,000**

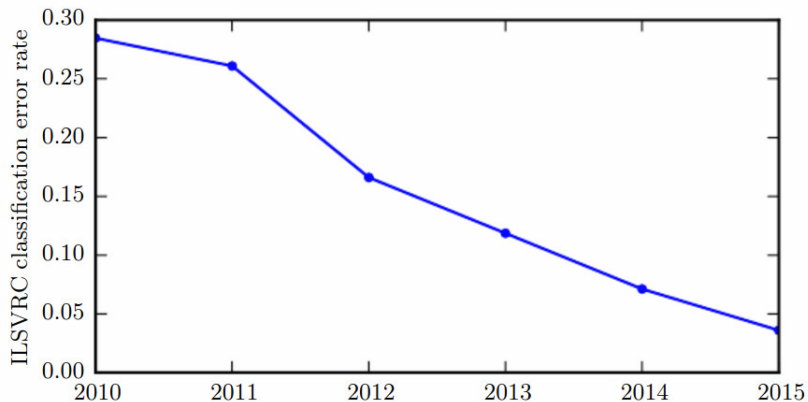
STANFORD AI LAB

3 GPU-Accelerated Servers  
12 GPUs • 18,432 cores

**4 kWatts**  
**\$33,000**



# Top-5 error in ILSVRC - It works!



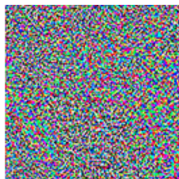
# Panda - It does not work!



"panda"

57.7% confidence

+  $\epsilon$



=



"gibbon"

99.3% confidence

# Deep learning Bongard?

The first rather amateurish attempt in 2018(!)

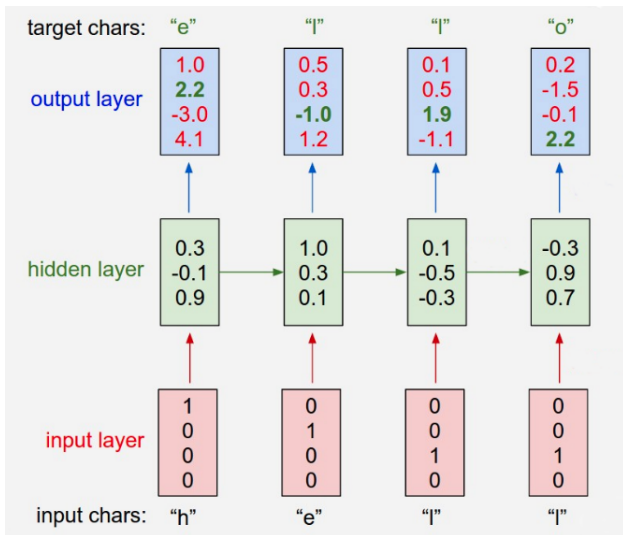
- ▶ Used synthetic data (insufficient number of true puzzles).
- ▶ Solved a classification version (10 images to "learn", classify remaining 2).
- ▶ Results for 232 "true" problems:
  - ▶ solved: 47,
  - ▶ correct: 41.
- ▶ That is, 20% of problems solved, with 87% accuracy.

# Questions ...

Question: Could you "tune" an AI program to act like me, or like you-or halfway between us?

Speculation: No. An intelligent program will not be chameleon-like, any more than people are. It will rely on the constancy of its memories, and will not be able to flit between personalities. The idea of changing internal parameters to "tune to a new personality" reveals a ridiculous underestimation of the complexity of personality.

# RNN generator



- ▶ Generating Shakespeare letter by letter.
- ▶ Trained on Shakespeare's plays (4.4MB).

VIOLA: Why, Salisbury must find his flesh and thought That which I am not apt, not a man and in fire, To show the reining of the raven and the wars To grace my hand reproach within, and not a fair are hand, That Caesar and my goodly father's world; When I was heaven of presence and our fleets, We spare with hours, but cut thy council I am great, Murdered and by thy master's ready there My power to give thee but so much as hell: Some service in the noble bondman here, Would show him to her wine.

KING LEAR: O, if you were a feeble sight, the courtesy of your law, Your sight and several breath, will wear the gods With his heads, and my hands are wonder'd at the deeds, So drop upon your lordship's head, and your opinion Shall be against your honour.

## ► Hutter Prize 100MB dataset from Wikipedia (96MB)

Naturalism and decision for the majority of Arab countries' capitalide was grounded by the Irish language by [[John Clair]], [[An Imperial Japanese Revolt]], associated with Guangzham's sovereignty. His generals were the powerful ruler of the Portugal in the [[Protestant Immineners]], which could be said to be directly in Cantonese Communication, which followed a ceremony and set inspired prison, training. The emperor travelled back to [[Antioch, Perth, October 25|21]] to note, the Kingdom of Costa Rica, unsuccessful fashioned the [[Thrales]], [[Cynth's Dajoard]], known in western [[Scotland]], near Italy to the conquest of India with the conflict. Copyright was the succession of independence in the slop of Syrian influence that was a famous German movement based on a more popular servicious, non-doctrinal and sexual power post. Many governments recognize the military housing of the [[Civil Liberalization and Infantry Resolution 265 National Party in Hungary]], that is sympathetic to be to the [[Punjab Resolution]] (PJS)[<http://www.humah.yahoo.com/guardian.cfm/7754800786d17551963s89.htm>

Official economics Adjoint for the Nazism, Montgomery was swear to

## Xml hallucination:

```
<page>
  <title>Antichrist</title>
  <id>865</id>
  <revision>
    <id>15900676</id>
    <timestamp>2002-08-03T18:14:12Z</timestamp>
    <contributor>
      <username>Paris</username>
      <id>23</id>
    </contributor>
    <minor />
    <comment>Automated conversion</comment>
    <text xml:space="preserve">
      #REDIRECT [[Christianity]]</text>
    </revision>
  </page>
```

- ▶ Algebraic geometry textbook.
- ▶ LaTeX source (16MB).
- ▶ Almost compilable.

*Proof.* Omitted. □

**Lemma 0.1.** *Let  $\mathcal{C}$  be a set of the construction.*

*Let  $\mathcal{C}$  be a gerber covering. Let  $\mathcal{F}$  be a quasi-coherent sheaves of  $\mathcal{O}$ -modules. We have to show that*

$$\mathcal{O}_{\mathcal{O}_X} = \mathcal{O}_X(\mathcal{L})$$

.

*Proof.* This is an algebraic space with the composition of sheaves  $\mathcal{F}$  on  $X_{\text{étale}}$  we have

$$\mathcal{O}_X(\mathcal{F}) = \{\text{morph}_1 \times_{\mathcal{O}_X} (\mathcal{G}, \mathcal{F})\}$$

where  $\mathcal{G}$  defines an isomorphism  $\mathcal{F} \rightarrow \mathcal{F}$  of  $\mathcal{O}$ -modules. □

**Lemma 0.2.** *This is an integer  $\mathcal{Z}$  is injective.*

*Proof.* See Spaces, Lemma ?? □

**Lemma 0.3.** *Let  $S$  be a scheme. Let  $X$  be a scheme and  $X$  is an affine open covering. Let  $\mathcal{U} \subset \mathcal{X}$  be a canonical and locally of finite type. Let  $X$  be a scheme. Let  $X$  be a scheme which is equal to the formal complex.*

*The following to the construction of the lemma follows.*

*Let  $X$  be a scheme. Let  $X$  be a scheme covering. Let*

$$b : X \rightarrow Y' \rightarrow Y \rightarrow Y \rightarrow Y' \times_X Y \rightarrow X.$$

*be a morphism of algebraic spaces over  $S$  and  $Y$ .*

*Proof.* Let  $X$  be a nonzero scheme of  $X$ . Let  $X$  be an algebraic space. Let  $\mathcal{F}$  be a quasi-coherent sheaf of  $\mathcal{O}_X$ -modules. The following are equivalent

- (1)  $\mathcal{F}$  is an algebraic space over  $S$ .
- (2) If  $X$  is an affine open covering.

Consider a common structure on  $X$  and  $X$  the functor  $\mathcal{O}_X(U)$  which is locally of

- ▶ Trained on all source files of Linux kernel concatenated into a single file (474MB of C code).

```

/*
 * Increment the size file of the new incorrect UI_FILTER group information
 * of the size generatively.
 */
static int indicate_policy(void)
{
    int error;
    if (fd == MARN_EPT) {
        /*
         * The kernel blank will coeld it to userspace.
         */
        if (ss->segment < mem_total)
            unblock_graph_and_set_blocked();
        else
            ret = 1;
        goto bail;
    }
    segaddr = in_SB(in.addr);
    selector = seg / 16;
    setup_works = true;
    for (i = 0; i < blocks; i++) {
        seq = buf[i++];
        bpf = bd->bd.next + i * search;
        if (fd) {
            current = blocked;
        }
    }
    rw->name = "Getjbbregs";
    bprm_self_clearl(&iv->version);
    regs->new = blocks[(BPF_STATS << info->historidac)] | PFMR_CLOBATHINC_SECONDS << 12;
    return segtable;
}

```

```

/*
 * Copyright (c) 2006-2010, Intel Mobile Communications. All rights reserved.
 *
 * This program is free software; you can redistribute it and/or modify it
 * under the terms of the GNU General Public License version 2 as published by
 * the Free Software Foundation.
 *
 * This program is distributed in the hope that it will be useful,
 * but WITHOUT ANY WARRANTY; without even the implied warranty of
 * MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the
 *
 * GNU General Public License for more details.
 *
 * You should have received a copy of the GNU General Public License
 * along with this program; if not, write to the Free Software Foundation,
 * Inc., 675 Mass Ave, Cambridge, MA 02139, USA.
 */

#include <linux/kexec.h>
#include <linux/errno.h>
#include <linux/io.h>
#include <linux/platform_device.h>
#include <linux/multi.h>
#include <linux/ckevent.h>

#include <asm/io.h>
#include <asm/prom.h>
#include <asm/e820.h>
#include <asm/system_info.h>
#include <asm/setew.h>
#include <asm/pgproto.h>

```

# Evolution of Shakespeare

## 100 iter.:

tyntd-iafhatawiaoihrdemot lytdws e ,tfti, astai f ogoh eoase rrranbyne 'nhthnee e  
plia tklrqd t o idoe ns,smtt h ne etie h,hregtrs nigtike,aoaenns lng

## 300 iter.:

"Tmont thithey" fomesscerliund  
Keushey. Thom here  
sheulke, anmerenith ol sivh I lalterthend Bleipile shuw y fil on aseterlome  
coaniogennc Phe lism thond hon at. MeiDimorotion in ther thize."

## 500 iter.:

we counter. He stutn co des. His stanted out one ofler that concossions and was  
to gearang reay Jotrets and with fre colt off paitt thin wall. Which das stimn

## 700 iter.:

Aftair fall unsuch that the hall for Prince Velzonski's that me of  
her hearly, and behs to so arwage fiving were to it beloge, pavu say falling misfort  
how, and Gogition is so overelical and ofter.

## 1200 iter.:

"Kite vouch!" he repeated by her  
door. "But I would be done and quarts, feeling, then, son is people...."

## 2000 iter.:

"Why do what that day," replied Natasha, and wishing to himself the fact the  
princess, Princess Mary was easier, fed in had oftened him.  
Pierre aking his soul came to the packs and drove up his father-in-law women.

DNA from nontheorems? It can be extended

We can't generate the desired loop below a MIU-system of question German and Warring's early dneadic.

Did I never tell you that did not see a less mirror of a popping-tonic

# Questions ...

Question: Will there be chess programs that can beat anyone?

Speculation: No. There may be programs which can beat anyone at chess, but they will not be exclusively chess players. They will be programs of general intelligence, and they will be just as temperamental as people.

Question: Will AI programs ever become "superintelligent"?

Speculation: I don't know. It is not clear that we would be able to understand or relate to a "superintelligence", or that the concept even makes sense. For instance, our own intelligence is tied in with our speed of thought. If our reflexes had been ten times faster or slower, we might have developed an entirely different set of concepts with which to describe the world.

# Game playing

How good is AI in playing games?

# Game playing

How good is AI in playing games?

GEB (1979):

- ▶ Man-programmed heuristics playing checkers (reasonably well)

# Game playing

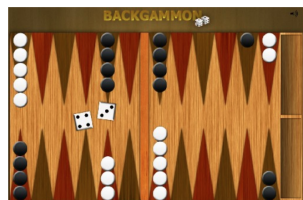
How good is AI in playing games?

GEB (1979):

- ▶ Man-programmed heuristics playing checkers (reasonably well)

Second "AI summer" (90s):

- ▶ Kasparov beaten by deep blue (1997)
- ▶ Tesauro: Reinforcement learning algorithm reached an expert level in backgammon by self-play (1995)



# Game playing

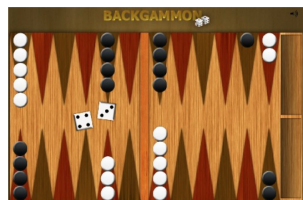
How good is AI in playing games?

GEB (1979):

- ▶ Man-programmed heuristics playing checkers (reasonably well)

Second "AI summer" (90s):

- ▶ Kasparov beaten by deep blue (1997)
- ▶ Tesauro: Reinforcement learning algorithm reached an expert level in backgammon by self-play (1995)



Current AI: Super-human skills reached by self-play in

- ▶ Go
- ▶ Chess
- ▶ Poker
- ▶ Starcraft

Question: Will a computer program ever write beautiful music?

Speculation: Yes, but not soon. Music is a language of emotions, and until programs have emotions as complex as ours, there is no way a program will write anything beautiful. There can be "forgeries" shallow imitations of the syntax of earlier music-but despite what one might think at first, there is much more to musical expression than can be captured in syntactical rules. There will be no new kinds of beauty turned up for a long time by computer music-composing programs.

... It would have to understand the joy and loneliness of a chilly night wind, the longing for a cherished hand, the inaccessibility of a distant town, the heartbreak and regeneration after a human death. It would have to have known resignation and worldweariness, grief and despair, determination and victory, piety and awe. In it would have had to commingle such opposites as hope and fear, anguish and jubilation, serenity and suspense. Part and parcel of it would have to be a sense of grace, humor, rhythm, a sense of the unexpected-and of course an exquisite awareness of the magic of fresh creation. Therein, and therein only, lie the sources of meaning in music.

In the first place would be if it were true, but so they really  
consider TNT.

(excerpt from GEB, 2. edition, Hofstadter AI et al)