

Making Mathematical Posters

Ulrich Hermisson and Robert V. Moody

Dept. of Mathematical and Statistical Sciences
University of Alberta, Edmonton, Alberta T6G 2G1, Canada
email: rmoody@uvic.ca

Abstract

We describe an undergraduate student project of making large mathematical posters, in LaTeX, for decorating mathematics department walls and lounges. A LaTeX style and a sample poster is included on the accompanying CD and as well a highly scaled down version of the same poster is included in this paper.

Travelling across southern India, one of us [RM] was fortunate enough to be invited to visit the famous temple city of Madurai and the Department of Mathematics of its Madurai Kamaraj University. One particularly nice feature of the Department is the set of posters that decorates its walls. Feeling that every mathematics student should be aware of the great problems and ideas in mathematics, the faculty had involved students in creating posters which introduced these as well as the history and personalities around them. Thus there were posters on the Fermat theorem, the Poincaré conjecture, the Riemann hypothesis, and so on. These were all done by the students, and they were all done by hand.

What a wonderful idea! The students who were directly involved in these projects got totally involved and inspired by rooting out and compiling the materials for the posters, the results are visually and intellectually interesting, and of course, subsequent students like to look at them, and in doing so absorb some of our great common mathematical culture and heritage.

Returning to the University of Alberta we thought to embark upon such a project here, but with one change. We would produce the posters in LaTeX which, though losing some of the charm of hand-made posters, would have the advantage of easier graphics, reproducibility, and a very professional appearance.

With the hard work of two summer students (Steven Pope and Sam Hillier) we have produced five posters. The first three were on these same three famous problems of mathematics just mentioned, but the last two moved more towards discussing some special areas of mathematics: one on Compact Lie Groups and one on The Halting Problem. Each poster is 30 inches wide and between 5 and 6 feet in length. They hang now, attractively framed, in the Department of Mathematical and Statistical Sciences here where they get constant attention and comment. A small representation of the Turing poster appears here: a full colour rendition may be found on the Renaissance Banff CD.

The task of creating a poster involves quite a number of skills: researching the subject or problem of the poster, learning about the mathematics and personalities involved, assembling this information and suitable graphic images in a coherent way which is informative but not overly technical, determining the layout and colour schemes, checking for accuracy, and then finally setting it into LaTeX.

We found that it was the last step that caused the most problems. Of course it is a very good idea for undergraduate mathematics students to be learning LaTeX. Although it is a bit of a learning curve, it is something that is necessary for future mathematicians to do anyway. But producing posters brings special problems. Very large fonts, lots of boxes, graphic elements, multi-column formatting, DVI viewers that do not live up to "what you see is what you get" on large files (most of them do not), and the high cost of trial and error printing, all conspire to make the final part of the process an exercise in patience, even if one already is familiar with LaTeX. It can be very discouraging for those just learning it. It is definitely best to have at least one computer-savvy person on the project!

Still, the potential here for exploring mathematics and making it available in a visually attractive way that can decorate the otherwise boring walls of mathematics departments and institutes is endless. With the hope of encouraging others to continue the process, we have produced here a basic schematic version of the LaTeX code that can be used to produce a poster. A copy of this can be downloaded from

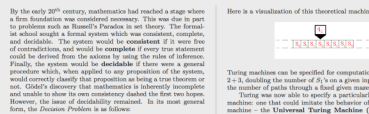
www.math.ualberta.ca/~rvmoody/rvm/

No doubt it will need some tweaking in any particular case, but this should be a sound basis on which to begin.

One other thing, production of more than a handful of posters or putting them up for sale would require obtaining suitable release for any images involved. We have not done

that with our posters, which is why we have only made a few copies of each.

The Halting Problem



Turing machine can be specified for computations such as adding 2 + 3, dividing the number of 5's on a given input tape, counting the number of bits that could be written in the behavior of any Turing machine - the Universal Turing Machine (UTM). Any machine can be converted to a Turing machine. Turing machine can be specified for computations such as adding 2 + 3, dividing the number of 5's on a given input tape, counting the number of bits that could be written in the behavior of any Turing machine - the Universal Turing Machine (UTM). Any machine can be converted to a Turing machine.

How many bits does it require to "effectively compute" these are three critical questions. At most finite in order to be considered effectively computable.

1. At content of a finite set of instructions, each of which contains a finite number of symbols.

2. There is no ambiguity in the instructions of M. That is, each instruction is clearly defined and always produces the same result.

3. M requires no extraneous information, only the set of instructions.

One such definition, now universally accepted, was given in 1936 by a young mathematician named Alan Turing. We might like to mention by mentioning the life of Alan Turing, and then considering his work on computability.

ALAN TURING WAS BORN on June 23, 1912 in Paddington, England, a suburb of London. His father Julius worked as an official in the Indian Civil Service. There to fulfill position the Turing family travelled incessantly between India and the United Kingdom. Alan and his brother John were born in India. In England. It was during this time that young Alan taught himself to read and write. While attending public school at King's College London, he discovered his aptitude for mathematics, but he also grew to dislike the rigid social structure of the time.



In 1931 Turing was a scholarship to King's College in Cambridge and began to study mathematics. He completed his undergraduate degree in 1934 and immediately began graduate study which included a course on the foundations of mathematics given by H. R. A. Newman. Shortly thereafter Turing's dissertation on the Central Limit Theorem was accepted, and he was granted a doctorate at King's College. With the freedom granted by the British government, Turing traveled to Princeton, New Jersey, where he was able to work in a working laboratory. His research and publications were highly influential in the field of computability.

In 1936 Turing transferred to the study high under Norman Church. Working in Princeton and Cambridge, he developed a theory of control logic to create automatic machines to incorporate results. However, this promising scientific work was interrupted in 1939 when Turing joined the British Government Code and Cipher School at the Turing realized first work for the war.

Based in Bletchley Park, Turing established what would eventually be his most famous project: deciphering the German Enigma code. The Enigma was a complex electromechanical machine which could be used to encrypt messages, but he was unable to decipher the messages. Turing's group developed machines, called Bombes, to perform the inverse calculation involved. This allowed them to decipher the messages.

While working on the Enigma, Turing met and fell in love with Joan Clarke, a brilliant mathematician who would prove to be an important communication system, which would prove to be instrumental to British success in World War II.

After the war, Turing went to work at the Mathematics Division of the National Physical Laboratory (NPL), a British government facility for advanced research. The post-war Alan Turing was keen to return to academic life. He was recruited by the British government to work at the Turing Institute in London. Turing's group developed machines, called Bombes, to perform the inverse calculation involved.

In 1947 Turing returned to Cambridge to resume work on his doctorate. His work centered on what other researchers had been calling "the Turing machine," and began studying physiology, cyberspace and artificial intelligence. Schemerized by transferred to Manchester in 1948 to utilize the early assembly built computer in the world at that time, and also to work again with Newman. For the remainder of his life he would study many diverse fields, including epidemiology, human intelligence and morphogenesis. Free from any sort of bureaucracy, Turing could live his life on his own terms.

The Bombes would not last. In 1952 following an unfortunate affair, Turing was arrested and charged with a homosexual offense. In the trial, this was considered a serious crime. Turing confessed to this crime and was sentenced to one year of hormone therapy, avoiding a prison sentence due to his knowledge. However, he was sentenced to avoid the inevitable social sanctions, being officially designated as a "person of no account." In the end, Turing decided to carry out his own experimentation, and the Turing machine to carry out his own experimentation. The act was designed to be a circumvent Computer Legislation (CCL). The act was designed to be a circumvent Computer Legislation (CCL). The act was designed to be a circumvent Computer Legislation (CCL). The act was designed to be a circumvent Computer Legislation (CCL).

TURING MACHINES Turing introduced his machines to represent the steps a human mathematician takes when solving a problem. The machine can be used to model any process that can be described by a finite set of instructions, now called an algorithm, that could be followed step by step by a machine to yield a result. In order to produce a result there would be no ambiguity or imagination involved on the part of the human computer. Turing's idea was that these machines could, in reality, what was considered effectively computable. Essentially, a Turing machine consists of:

1. A finite set of symbols $\{S_1, S_2, \dots, S_n\}$, in fact two symbols are sufficient.

2. A potentially infinite 1-dimensional tape, written into equal spaces. Each space is capable of holding precisely one symbol.

3. A scanning head that rests on one square of the tape at any given time, but has the ability to read and write symbols on that square, and that can move one square either left or right from the square it is on.

4. A finite set of internal configurations, or simply the states of the machine $\{q_1, q_2, \dots, q_n\}$, together with a finite set of instructions, which are conditional of the form:

If q_i and S_j are read, then write symbol S_k on the tape, then move S_j point S_l and assume state q_m .

The possible actions of M are now left one square, now right one square or no move at all.

We also define the input of the Turing machine as the initial state of the tape. The machine is defined to start in state q_1 .

REFERENCES

- Rosen, William W. "The Word Problem." *Annals of Mathematics*, 70 (1959), 316-320.
- Hopkins, Andrew. *Alan Turing: The Enigma*. London: Vintage, 1982.
- Morris, Stephen. *Alan Turing: The Man Behind the Code*. New York: HarperCollins, 1983.
- Moore, John. *Alan Turing: The Enigma*. London: Profile, 1983.
- Turing, Alan. *Computing Machinery and Intelligence*. *Mind*, 59 (1950), 109-152.
- Turing, Alan. *Computing Machinery and Intelligence*. *Proceedings of the London Mathematical Society*, 50 (1951), 231-238.

This is a visualization of this theoretical machine.

Turing machine can be specified for computations such as adding 2 + 3, dividing the number of 5's on a given input tape, counting the number of bits that could be written in the behavior of any Turing machine - the Universal Turing Machine (UTM). Any machine can be converted to a Turing machine. Turing machine can be specified for computations such as adding 2 + 3, dividing the number of 5's on a given input tape, counting the number of bits that could be written in the behavior of any Turing machine - the Universal Turing Machine (UTM). Any machine can be converted to a Turing machine.

How many bits does it require to "effectively compute" these are three critical questions. At most finite in order to be considered effectively computable.

1. At content of a finite set of instructions, each of which contains a finite number of symbols.

2. There is no ambiguity in the instructions of M. That is, each instruction is clearly defined and always produces the same result.

3. M requires no extraneous information, only the set of instructions.

One such definition, now universally accepted, was given in 1936 by a young mathematician named Alan Turing. We might like to mention by mentioning the life of Alan Turing, and then considering his work on computability.

ALAN TURING WAS BORN on June 23, 1912 in Paddington, England, a suburb of London. His father Julius worked as an official in the Indian Civil Service. There to fulfill position the Turing family travelled incessantly between India and the United Kingdom. Alan and his brother John were born in India. In England. It was during this time that young Alan taught himself to read and write. While attending public school at King's College London, he discovered his aptitude for mathematics, but he also grew to dislike the rigid social structure of the time.

In 1931 Turing was a scholarship to King's College in Cambridge and began to study mathematics. He completed his undergraduate degree in 1934 and immediately began graduate study which included a course on the foundations of mathematics given by H. R. A. Newman. Shortly thereafter Turing's dissertation on the Central Limit Theorem was accepted, and he was granted a doctorate at King's College. With the freedom granted by the British government, Turing traveled to Princeton, New Jersey, where he was able to work in a working laboratory. His research and publications were highly influential in the field of computability.

In 1936 Turing transferred to the study high under Norman Church. Working in Princeton and Cambridge, he developed a theory of control logic to create automatic machines to incorporate results. However, this promising scientific work was interrupted in 1939 when Turing joined the British Government Code and Cipher School at the Turing realized first work for the war.

Based in Bletchley Park, Turing established what would eventually be his most famous project: deciphering the German Enigma code. The Enigma was a complex electromechanical machine which could be used to encrypt messages, but he was unable to decipher the messages. Turing's group developed machines, called Bombes, to perform the inverse calculation involved.

While working on the Enigma, Turing met and fell in love with Joan Clarke, a brilliant mathematician who would prove to be an important communication system, which would prove to be instrumental to British success in World War II.

After the war, Turing went to work at the Mathematics Division of the National Physical Laboratory (NPL), a British government facility for advanced research. The post-war Alan Turing was keen to return to academic life. He was recruited by the British government to work at the Turing Institute in London. Turing's group developed machines, called Bombes, to perform the inverse calculation involved.

In 1947 Turing returned to Cambridge to resume work on his doctorate. His work centered on what other researchers had been calling "the Turing machine," and began studying physiology, cyberspace and artificial intelligence. Schemerized by transferred to Manchester in 1948 to utilize the early assembly built computer in the world at that time, and also to work again with Newman. For the remainder of his life he would study many diverse fields, including epidemiology, human intelligence and morphogenesis. Free from any sort of bureaucracy, Turing could live his life on his own terms.

The Bombes would not last. In 1952 following an unfortunate affair, Turing was arrested and charged with a homosexual offense. In the trial, this was considered a serious crime. Turing confessed to this crime and was sentenced to one year of hormone therapy, avoiding a prison sentence due to his knowledge. However, he was sentenced to avoid the inevitable social sanctions, being officially designated as a "person of no account." In the end, Turing decided to carry out his own experimentation, and the Turing machine to carry out his own experimentation. The act was designed to be a circumvent Computer Legislation (CCL). The act was designed to be a circumvent Computer Legislation (CCL). The act was designed to be a circumvent Computer Legislation (CCL).

TURING MACHINES Turing introduced his machines to represent the steps a human mathematician takes when solving a problem. The machine can be used to model any process that can be described by a finite set of instructions, now called an algorithm, that could be followed step by step by a machine to yield a result. In order to produce a result there would be no ambiguity or imagination involved on the part of the human computer. Turing's idea was that these machines could, in reality, what was considered effectively computable. Essentially, a Turing machine consists of:

1. A finite set of symbols $\{S_1, S_2, \dots, S_n\}$, in fact two symbols are sufficient.

2. A potentially infinite 1-dimensional tape, written into equal spaces. Each space is capable of holding precisely one symbol.

3. A scanning head that rests on one square of the tape at any given time, but has the ability to read and write symbols on that square, and that can move one square either left or right from the square it is on.

4. A finite set of internal configurations, or simply the states of the machine $\{q_1, q_2, \dots, q_n\}$, together with a finite set of instructions, which are conditional of the form:

If q_i and S_j are read, then write symbol S_k on the tape, then move S_j point S_l and assume state q_m .

The possible actions of M are now left one square, now right one square or no move at all.

We also define the input of the Turing machine as the initial state of the tape. The machine is defined to start in state q_1 .

REFERENCES

- Rosen, William W. "The Word Problem." *Annals of Mathematics*, 70 (1959), 316-320.
- Hopkins, Andrew. *Alan Turing: The Enigma*. London: Vintage, 1982.
- Morris, Stephen. *Alan Turing: The Man Behind the Code*. New York: HarperCollins, 1983.
- Moore, John. *Alan Turing: The Enigma*. London: Profile, 1983.
- Turing, Alan. *Computing Machinery and Intelligence*. *Mind*, 59 (1950), 109-152.
- Turing, Alan. *Computing Machinery and Intelligence*. *Proceedings of the London Mathematical Society*, 50 (1951), 231-238.

The Fibonacci numbers are Diophantine. This provided the crucial missing step in a proof that had been developed before by Martin Davis, Hilary Putnam and Julia Robinson.

The result of this is that Turing machines are incapable of deciding whether or not the equations belonging to some particular family of Diophantine equations have solutions, to our existing knowledge of number theory.

THE TILING PROBLEM The Tiling Problem is a decision problem concerning tiling the plane with a finite number of types of tiles. One is given a finite collection of tiles and is asked to determine whether or not these tiles can tile the plane. The problem is to decide whether or not this can be done. It is a decision problem, meaning that the answer is either yes or no. The problem is to decide whether or not this can be done. It is a decision problem, meaning that the answer is either yes or no. The problem is to decide whether or not this can be done. It is a decision problem, meaning that the answer is either yes or no. The problem is to decide whether or not this can be done. It is a decision problem, meaning that the answer is either yes or no.

Robert Berger, a student of Wang's, discovered this conjecture by showing that the tiling problem was undecidable. This opened the door for tilings that cannot be done periodically. These are called non-periodic tilings. The first such set was given by Berger, consisting of 20,109 distinct polygons. Other examples were constructed by Hao Wang, Donald Knuth and others.

ROBERT BERGER was a student of Wang's, discovered this conjecture by showing that the tiling problem was undecidable. This opened the door for tilings that cannot be done periodically. These are called non-periodic tilings. The first such set was given by Berger, consisting of 20,109 distinct polygons. Other examples were constructed by Hao Wang, Donald Knuth and others.

HAO WANG was a student of Wang's, discovered this conjecture by showing that the tiling problem was undecidable. This opened the door for tilings that cannot be done periodically. These are called non-periodic tilings. The first such set was given by Berger, consisting of 20,109 distinct polygons. Other examples were constructed by Hao Wang, Donald Knuth and others.

DONALD KNUTH was a student of Wang's, discovered this conjecture by showing that the tiling problem was undecidable. This opened the door for tilings that cannot be done periodically. These are called non-periodic tilings. The first such set was given by Berger, consisting of 20,109 distinct polygons. Other examples were constructed by Hao Wang, Donald Knuth and others.

HAO WANG was a student of Wang's, discovered this conjecture by showing that the tiling problem was undecidable. This opened the door for tilings that cannot be done periodically. These are called non-periodic tilings. The first such set was given by Berger, consisting of 20,109 distinct polygons. Other examples were constructed by Hao Wang, Donald Knuth and others.

HAO WANG was a student of Wang's, discovered this conjecture by showing that the tiling problem was undecidable. This opened the door for tilings that cannot be done periodically. These are called non-periodic tilings. The first such set was given by Berger, consisting of 20,109 distinct polygons. Other examples were constructed by Hao Wang, Donald Knuth and others.

HAO WANG was a student of Wang's, discovered this conjecture by showing that the tiling problem was undecidable. This opened the door for tilings that cannot be done periodically. These are called non-periodic tilings. The first such set was given by Berger, consisting of 20,109 distinct polygons. Other examples were constructed by Hao Wang, Donald Knuth and others.

HAO WANG was a student of Wang's, discovered this conjecture by showing that the tiling problem was undecidable. This opened the door for tilings that cannot be done periodically. These are called non-periodic tilings. The first such set was given by Berger, consisting of 20,109 distinct polygons. Other examples were constructed by Hao Wang, Donald Knuth and others.

HAO WANG was a student of Wang's, discovered this conjecture by showing that the tiling problem was undecidable. This opened the door for tilings that cannot be done periodically. These are called non-periodic tilings. The first such set was given by Berger, consisting of 20,109 distinct polygons. Other examples were constructed by Hao Wang, Donald Knuth and others.

HAO WANG was a student of Wang's, discovered this conjecture by showing that the tiling problem was undecidable. This opened the door for tilings that cannot be done periodically. These are called non-periodic tilings. The first such set was given by Berger, consisting of 20,109 distinct polygons. Other examples were constructed by Hao Wang, Donald Knuth and others.

HAO WANG was a student of Wang's, discovered this conjecture by showing that the tiling problem was undecidable. This opened the door for tilings that cannot be done periodically. These are called non-periodic tilings. The first such set was given by Berger, consisting of 20,109 distinct polygons. Other examples were constructed by Hao Wang, Donald Knuth and others.

HAO WANG was a student of Wang's, discovered this conjecture by showing that the tiling problem was undecidable. This opened the door for tilings that cannot be done periodically. These are called non-periodic tilings. The first such set was given by Berger, consisting of 20,109 distinct polygons. Other examples were constructed by Hao Wang, Donald Knuth and others.

HAO WANG was a student of Wang's, discovered this conjecture by showing that the tiling problem was undecidable. This opened the door for tilings that cannot be done periodically. These are called non-periodic tilings. The first such set was given by Berger, consisting of 20,109 distinct polygons. Other examples were constructed by Hao Wang, Donald Knuth and others.

HAO WANG was a student of Wang's, discovered this conjecture by showing that the tiling problem was undecidable. This opened the door for tilings that cannot be done periodically. These are called non-periodic tilings. The first such set was given by Berger, consisting of 20,109 distinct polygons. Other examples were constructed by Hao Wang, Donald Knuth and others.

HAO WANG was a student of Wang's, discovered this conjecture by showing that the tiling problem was undecidable. This opened the door for tilings that cannot be done periodically. These are called non-periodic tilings. The first such set was given by Berger, consisting of 20,109 distinct polygons. Other examples were constructed by Hao Wang, Donald Knuth and others.

HAO WANG was a student of Wang's, discovered this conjecture by showing that the tiling problem was undecidable. This opened the door for tilings that cannot be done periodically. These are called non-periodic tilings. The first such set was given by Berger, consisting of 20,109 distinct polygons. Other examples were constructed by Hao Wang, Donald Knuth and others.

HAO WANG was a student of Wang's, discovered this conjecture by showing that the tiling problem was undecidable. This opened the door for tilings that cannot be done periodically. These are called non-periodic tilings. The first such set was given by Berger, consisting of 20,109 distinct polygons. Other examples were constructed by Hao Wang, Donald Knuth and others.

HAO WANG was a student of Wang's, discovered this conjecture by showing that the tiling problem was undecidable. This opened the door for tilings that cannot be done periodically. These are called non-periodic tilings. The first such set was given by Berger, consisting of 20,109 distinct polygons. Other examples were constructed by Hao Wang, Donald Knuth and others.