2024-12-08 On the Geometry of Time.

Given an array of n positions requires n+1 indexes.

1. A month as 30 degrees requires 31 indexes
2. A quarter for 90 degrees requires 91 indexes
3. A year for 360 degrees requires 361 indexes.

Then, 4×91idx=364 when a year requires +1idx for 365idx total geometrically.

This pattern continues to any unit of time with 60 degrees in seconds and minutes to the 12 radians of 2 sides of pi for 24 hour days.

Thus, time is a geometric curve.

On the Geometry of Time LaTeX Preprint

```latex
\documentclass[12pt]{article}
\usepackage{amsmath}
\usepackage{graphicx}
\usepackage{tikz}
\usepackage{float}
\usepackage{amsthm}
\usepackage{physics}
\usepackage{braket}
\usepackage{qcircuit}
\usepackage{hyperref}
\usepackage{cleveref}

\title{On the Geometry of Time: \\
\large Quantum Financial Analytics through Geometric Temporal Mapping}
\author{Taylor Metz, CPA, BBA, unaff.}
\date{2024-04-17}

\begin{document}

\maketitle

\begin{abstract}
We present a novel theoretical framework unifying temporal geometry with
quantum computation for financial analysis. By mapping temporal cycles to
quantum states through specialized gates, we demonstrate how cyclotomic
properties of time intervals naturally align with quantum computational
structures. The framework leverages Bloch sphere representations and Toffoli-
like gates to process temporal-financial data, offering new approaches to
```

```latex
quantum financial modeling. This work bridges fundamental physics, quantum
computation, and financial analysis through geometric temporal mapping.
\end{abstract}

\section{Introduction}

Given an array of $n$ positions requires $n+1$ indexes, we observe fundamental
geometric properties in temporal measurements:

\begin{enumerate}
    \item A month as 30 degrees requires 31 indexes
    \item A quarter for 90 degrees requires 91 indexes
    \item A year for 360 degrees requires 361 indexes
\end{enumerate}

Then, $4 \times 91\text{idx} = 364$ when a year requires $+1\text{idx}$ for
$365\text{idx}$ total geometrically.

\section{Quantum Circuit Implementation}

\subsection{Gate Structure and Bloch Sphere Mapping}

Our quantum implementation utilizes a modified Toffoli gate structure
\cite{toffoli1980reversible} mapped to temporal cycles. The fundamental gates
are:

\begin{equation}
U(\theta, \phi) =
\begin{pmatrix}
\cos(\theta/2) & -e^{-i\phi}\sin(\theta/2) \\
e^{i\phi}\sin(\theta/2) & \cos(\theta/2)
\end{pmatrix}
\end{equation}

Where $\theta$ represents temporal rotation and $\phi$ represents phase
alignment with financial periods.

The Bloch sphere representation maps temporal states to quantum states
through:

\begin{equation}
\ket{\psi} = \cos(\theta/2)\ket{0} + e^{i\phi}\sin(\theta/2)\ket{1}
\end{equation}

Where $\theta$ and $\phi$ correspond to temporal coordinates on our 360-degree
mapping.
```

```latex
\subsection{Modified Toffoli Gate Implementation}

Our temporal Toffoli gate operates on three qubits:
\begin{itemize}
    \item Control qubit 1 (C1): Temporal index
    \item Control qubit 2 (C2): Financial state
    \item Target qubit (T): Quantum financial output
\end{itemize}

The gate operation follows:
\begin{equation}
\text{TCCT}(\ket{x},\ket{y},\ket{z}) = \ket{x},\ket{y},\ket{z \oplus (x \cdot
y)}
\end{equation}

This creates a natural mapping to our temporal cycles:
\begin{equation}
\begin{cases}
    x = \text{temporal index mod 91} \\
    y = \text{financial state} \\
    z = \text{quantum financial output}
\end{cases}
\end{equation}

\subsection{Quantum Circuit Diagram}

\begin{figure}[H]
\centering
\begin{quantikz}
\lstick{\ket{x}} & \ctrl{1} & \ctrl{2} & \qw \\
\lstick{\ket{y}} & \ctrl{1} & \qw & \qw \\
\lstick{\ket{z}} & \targ{} & \gate{U(\theta,\phi)} & \qw
\end{quantikz}
\caption{Temporal-Quantum Financial Circuit}
\label{fig:quantum_circuit}
\end{figure}

\section{Cyclotomic Properties and Bloch Sphere Representation}

The 91-index structure derives from cyclotomic integers 13 and 7, mapping to
the Bloch sphere through:

\begin{equation}
\begin{pmatrix}
\cos(2\pi/13) & -\sin(2\pi/13) \\
```

```latex
\sin(2\pi/13) & \cos(2\pi/13)
\end{pmatrix}
\otimes
\begin{pmatrix}
\cos(2\pi/7) & -\sin(2\pi/7) \\
\sin(2\pi/7) & \cos(2\pi/7)
\end{pmatrix}
\end{equation}

This creates a natural mapping between temporal rotations and quantum states.

\section{Quantum Financial State Space}

The quantum financial state space $\mathcal{F}$ is defined as:

\begin{equation}
\mathcal{F} = \{\ket{\psi_f} = \alpha\ket{0} + \beta\ket{1} : |\alpha|^2 +
|\beta|^2 = 1\}
\end{equation}

Where financial states map to the Bloch sphere through:
\begin{equation}
\ket{\psi_f} = \cos(\theta/2)\ket{0} + e^{i\phi}\sin(\theta/2)\ket{1}
\end{equation}

This creates a complete representation where:
\begin{itemize}
    \item $\theta$ represents temporal position
    \item $\phi$ represents financial phase
    \item $\ket{0}$ and $\ket{1}$ represent binary financial states
\end{itemize}

\section{Buoyant Satisfiability and State Convergence}

The system demonstrates buoyant satisfiability through quantum state
convergence:

\begin{equation}
\lim_{t \to \infty} \bra{\psi_f(t)}H\ket{\psi_f(t)} = E_{min}
\end{equation}

Where $H$ is the system Hamiltonian and $E_{min}$ represents the optimal
financial state.

\section{Applications to Financial Analysis}
```

```latex
\subsection{Temporal-Quantum Period Normalization}

For financial period alignment:
\begin{equation}
Q = U(\theta,\phi)\ket{\psi_f} = \ket{\psi_f'}
\end{equation}

Where $\ket{\psi_f'}$ represents the normalized financial state.

\subsection{Market State Superposition}

Market uncertainties are represented through superposition:
\begin{equation}
\ket{\psi_m} = \sum_{i} c_i\ket{i}
\end{equation}

Where $c_i$ represents probability amplitudes for different market states.

\section{Future Research Directions}

This framework opens several research directions:
\begin{itemize}
    \item Extended quantum circuit implementations
    \item Advanced financial state mapping
    \item Temporal data compression algorithms
\end{itemize}

\section{Conclusion}

This unified framework provides a foundation for quantum financial analysis
through temporal geometry, offering new approaches to financial modeling and
quantum computation.

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Automata, Languages, and Programming (pp. 632-644). Springer.

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79.
```

```latex
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\end{thebibliography}

\end{document}
```

Appendix I - Geometric Representation of Time

```svg
<svg viewBox="0 0 600 400" xmlns="http://www.w3.org/2000/svg">
    <!-- Background -->
    <rect width="600" height="400" fill="#fafafa"/>

    <!-- Year Circle (360 degrees + 1 index) -->
    <circle cx="300" cy="200" r="150" fill="none" stroke="#2563eb" stroke-
width="2"/>
    <text x="300" y="30" text-anchor="middle" fill="#2563eb">Year: 360° (361
indexes)</text>

    <!-- Quarter Circles (90 degrees + 1 index each) -->
    <path d="M300 50 A150 150 0 0 1 450 200" fill="none" stroke="#059669"
stroke-width="2"/>
    <path d="M450 200 A150 150 0 0 1 300 350" fill="none" stroke="#059669"
stroke-width="2"/>
    <path d="M300 350 A150 150 0 0 1 150 200" fill="none" stroke="#059669"
stroke-width="2"/>
    <path d="M150 200 A150 150 0 0 1 300 50" fill="none" stroke="#059669"
stroke-width="2"/>
    <text x="480" y="200" fill="#059669">Q1: 91 idx</text>
    <text x="300" y="380" fill="#059669">Q2: 91 idx</text>
    <text x="120" y="200" fill="#059669">Q3: 91 idx</text>
    <text x="300" y="80" fill="#059669">Q4: 91 idx</text>

    <!-- Month Arc (30 degrees + 1 index) -->
    <path d="M300 50 A150 150 0 0 1 375 75" fill="none" stroke="#dc2626"
```

```
stroke-width="2"/>
    <text x="390" y="90" fill="#dc2626">Month: 30° (31 idx)</text>

    <!-- Center Point -->
    <circle cx="300" cy="200" r="3" fill="black"/>
    <text x="310" y="205" fill="black">Origin</text>

    <!-- Imaginary Index Representation -->
    <line x1="300" y1="200" x2="300" y2="100" stroke="#6366f1" stroke-
width="2" stroke-dasharray="4"/>
    <text x="320" y="150" fill="#6366f1">Imaginary Index</text>
</svg>
```

Appendix II - Discrete Financial Normalization

```
<svg viewBox="0 0 800 400" xmlns="http://www.w3.org/2000/svg">
    <!-- Background -->
    <rect width="800" height="400" fill="#fafafa"/>

    <!-- Period Normalization Flow -->
    <g transform="translate(50,50)">
        <!-- Input Month Box -->
        <rect x="0" y="0" width="120" height="60" fill="none" stroke="#2563eb"
stroke-width="2"/>
        <text x="60" y="35" text-anchor="middle" fill="#2563eb">Input Month
M</text>

        <!-- Mod 12 Operation -->
        <path d="M120 30 H200" stroke="#059669" stroke-width="2" marker-
end="url(#arrow)"/>
        <rect x="200" y="0" width="120" height="60" fill="none"
stroke="#059669" stroke-width="2"/>
        <text x="260" y="25" text-anchor="middle" fill="#059669">mod 12</text>
        <text x="260" y="45" text-anchor="middle" fill="#059669">(M - S) mod
12</text>

        <!-- Divide by 3 -->
        <path d="M320 30 H400" stroke="#dc2626" stroke-width="2" marker-
end="url(#arrow)"/>
        <rect x="400" y="0" width="120" height="60" fill="none"
stroke="#dc2626" stroke-width="2"/>
        <text x="460" y="25" text-anchor="middle" fill="#dc2626">÷ 3</text>
        <text x="460" y="45" text-anchor="middle" fill="#dc2626">Quarter
Alignment</text>
```

```
        <!-- Mod 4 Operation -->
        <path d="M520 30 H600" stroke="#6366f1" stroke-width="2" marker-
end="url(#arrow)"/>
        <rect x="600" y="0" width="120" height="60" fill="none"
stroke="#6366f1" stroke-width="2"/>
        <text x="660" y="25" text-anchor="middle" fill="#6366f1">mod 4</text>
        <text x="660" y="45" text-anchor="middle" fill="#6366f1">Discrete
Quarter</text>
    </g>

    <!-- Quarter Mapping Circle -->
    <g transform="translate(200,200)">
        <circle cx="200" cy="100" r="80" fill="none" stroke="#2563eb" stroke-
width="2"/>
        <!-- Quarter divisions -->
        <line x1="200" y1="20" x2="200" y2="180" stroke="#2563eb" stroke-
width="1" stroke-dasharray="4"/>
        <line x1="120" y1="100" x2="280" y2="100" stroke="#2563eb" stroke-
width="1" stroke-dasharray="4"/>
        <!-- Quarter labels -->
        <text x="200" y="35" text-anchor="middle">Q1</text>
        <text x="265" y="100" text-anchor="middle">Q2</text>
        <text x="200" y="170" text-anchor="middle">Q3</text>
        <text x="135" y="100" text-anchor="middle">Q4</text>
    </g>

    <!-- Explanation -->
    <text x="50" y="350" fill="black" font-size="14">Where: M = Report Month,
S = Start Month</text>
    <text x="50" y="375" fill="black" font-size="14">Result: Normalized
Quarter Q ∈ {0,1,2,3}</text>

    <!-- Arrow marker definition -->
    <defs>
        <marker id="arrow" markerWidth="10" markerHeight="10" refX="9"
refY="3" orient="auto" markerUnits="strokeWidth">
            <path d="M0,0 L0,6 L9,3 z" fill="#black"/>
        </marker>
    </defs>
</svg>
```

Appendix III - Quantum Application in Toffelini Gates

```
<svg viewBox="0 0 800 400" xmlns="http://www.w3.org/2000/svg">
    <!-- Background -->
```

```
    <rect width="800" height="400" fill="#fafafa"/>

    <!-- Quantum Circuit Region -->
    <g transform="translate(50,50)">
        <!-- Qubit lines -->
        <line x1="0" y1="0" x2="700" y2="0" stroke="#2563eb" stroke-width="2"/>
        <line x1="0" y1="50" x2="700" y2="50" stroke="#2563eb" stroke-width="2"/>
        <line x1="0" y1="100" x2="700" y2="100" stroke="#2563eb" stroke-width="2"/>

        <!-- Gates -->
        <rect x="100" y="-10" width="40" height="120" fill="none" stroke="#059669" stroke-width="2"/>
        <text x="115" y="50" text-anchor="middle" fill="#059669">G1</text>

        <rect x="300" y="-10" width="40" height="120" fill="none" stroke="#059669" stroke-width="2"/>
        <text x="315" y="50" text-anchor="middle" fill="#059669">G2</text>

        <rect x="500" y="-10" width="40" height="120" fill="none" stroke="#059669" stroke-width="2"/>
        <text x="515" y="50" text-anchor="middle" fill="#059669">G3</text>
    </g>

    <!-- Temporal Mapping -->
    <g transform="translate(50,200)">
        <!-- 360° circle divided into 91-index segments -->
        <circle cx="350" cy="100" r="80" fill="none" stroke="#dc2626" stroke-width="2"/>

        <!-- 90° divisions -->
        <line x1="350" y1="20" x2="350" y2="180" stroke="#dc2626" stroke-width="1" stroke-dasharray="4"/>
        <line x1="270" y1="100" x2="430" y2="100" stroke="#dc2626" stroke-width="1" stroke-dasharray="4"/>

        <!-- Bit mapping indicators -->
        <text x="350" y="0" text-anchor="middle" fill="#6366f1">13 bits</text>
        <text x="450" y="100" text-anchor="start" fill="#6366f1">7 bits</text>
    </g>

    <!-- Labels -->
    <text x="50" y="30" fill="black" font-weight="bold">Quantum Circuit</text>
    <text x="50" y="180" fill="black" font-weight="bold">Temporal
```

```
Mapping</text>
</svg>
```

Simplified Version

```
\documentclass{article}
\usepackage{amsmath}

\title{On the Geometry of Time}
\author{Taylor Metz, CPA, BBA, unaff.}
\date{2024-04-17}

\begin{document}

\maketitle

Given an array of $n$ positions requires $n+1$ indexes.

\begin{enumerate}
    \item A month as 30 degrees requires 31 indexes
    \item A quarter for 90 degrees requires 91 indexes
    \item A year for 360 degrees requires 361 indexes
\end{enumerate}

Then, $4 \times 91\text{idx} = 364$ when a year requires $+1\text{idx}$ for
$365\text{idx}$ total geometrically.

This pattern continues to any unit of time with 60 degrees in seconds and
minutes to the 12 radians of 2 sides of $\pi$ for 24 hour days.

Thus, time is a geometric curve.

\section{Deriving the Index Positions from Cyclotomic Integers}

The 91 index positions for each quarter of the year can be derived using the
cyclotomic integers 13 and 7. These numbers have interesting properties that
relate to the geometric structure of time.

Consider the integer 8, which is one less than the number of bits in a byte (7
bits for data and 1 bit for sign). We can represent the 91 index positions as
a 7-bit integer with the least significant bit missing.

Alternatively, we can view the 91 positions as a 16-bit floating-point number,
where we have 13 bits for the mantissa (XYZ coordinates in three-dimensional
```

space) and 3 bits for the exponent (reserved header). The 3 missing bits in the mantissa correspond to the cyclotomic integer 13, while the 7 bits for data in the byte representation relate to the cyclotomic integer 7.

This connection between the 91 index positions and the cyclotomic integers 13 and 7 suggests a deep link between the geometry of time and fundamental mathematical structures. It hints at the possibility of representing temporal patterns using compact and efficient data types, leveraging the inherent symmetries and relationships encoded in these numbers.

Further exploration of the properties of cyclotomic integers and their connection to the geometry of time may yield additional insights and applications. It could potentially lead to new ways of compressing, storing, and manipulating temporal data, as well as uncovering deeper connections between time, space, and number theory.

\section{The Imaginary Index}

The geometric nature of time suggests an additional ``imaginary'' index or dimension beyond the real-valued indexes we typically consider. This imaginary index represents the completion of one cycle and the transition to the next, bridging the gap between the end of one rotation and the beginning of another.

In the context of a year, the imaginary 365th index connects December 31st to January 1st, allowing the cycle to repeat indefinitely. Similarly, for other units of time like days or months, the imaginary index provides the link that closes the loop and enables the recurring pattern.

The presence of this imaginary index has profound implications for our understanding of time and its fundamental structure. It suggests that time is not merely a linear progression but a complex geometric object with both real and imaginary components.

\section{Application to Financial Analysis and Quantum Finance}

The geometric nature of time and the use of modular arithmetic can have practical applications in fields such as financial analysis and quantum finance. One such application is the alignment of financial periods with calendar months to remove external shocks and facilitate multi-variant analysis.

Consider a scenario where financial data is reported using different fiscal year-ends across various entities. To compare and analyze this data effectively, it is necessary to normalize the time periods to a common reference point, such as the calendar year starting in January.

```latex
We can achieve this normalization by applying the following modular arithmetic
approach:

\begin{enumerate}
    \item Calculate the difference between the month of the financial period
end and the desired starting month (e.g., January).
    \item Take the modulo 12 of this difference to handle wrap-around cases.
    \item Divide the result by 3 and take the modulo 4 to quantize the
difference into quarterly buckets.
\end{enumerate}

Mathematically, this can be expressed as:

\begin{equation}
Q = \left(\left(M - S\right) \bmod 12\right) \div 3 \bmod 4
\end{equation}

where $Q$ is the quantized difference, $M$ is the month of the financial
period end, and $S$ is the desired starting month (e.g., 1 for January).

By applying this transformation, we can effectively align financial data from
different sources to a common calendar-based reference point, removing the
impact of varying fiscal year-ends. This alignment enables more accurate and
meaningful comparisons, facilitating tasks such as multi-variant analysis and
the study of financial market dynamics.

Furthermore, this modular arithmetic approach can be extended to the realm of
quantum finance, where the inherent cyclical nature of time and the presence
of quantum effects may require novel techniques for handling temporal data. By
leveraging the geometric properties of time and the power of modular
arithmetic, researchers can develop new algorithms and models that capture the
unique characteristics of financial systems in the quantum domain.

The application of the geometric perspective on time to financial analysis and
quantum finance demonstrates the potential for this framework to yield
practical insights and drive innovation across various domains. As we continue
to explore the implications of this approach, we may uncover new ways to
harness the structure of time for more accurate and efficient financial
modeling and decision-making.

\section{Conclusion}
[Previous L

\section{Temporal Normalization for Financial Analysis}
```

```latex
\subsection{Period Normalization Algorithm}

To remove temporal noise from financial reporting periods, we implement a
discrete quantization process:

\begin{equation}
Q = \left(\left(\left(M - S\right) \bmod 12\right) \div 3\right) \bmod 4
\end{equation}

Where:
\begin{itemize}
    \item $Q$ is the normalized quarter index
    \item $M$ is the financial reporting month
    \item $S$ is the starting month of the fiscal year
\end{itemize}

This transformation provides several key benefits:
\begin{enumerate}
    \item Removes fiscal year-end timing differences
    \item Quantizes continuous time series into discrete quarters
    \item Eliminates external noise from reporting period misalignment
\end{enumerate}

\subsection{Quantum State Mapping}

The normalized quarters map to quantum states through:

\begin{equation}
\ket{Q} = \sum_{i=0}^{3} \alpha_i\ket{i}
\end{equation}

Where $\alpha_i$ represents the amplitude for each quarter state.

\subsection{Noise Reduction Properties}

The modular arithmetic operations provide natural noise reduction:
\begin{itemize}
    \item mod 12: Eliminates yearly cycle variations
    \item ÷ 3: Aligns with natural quarter boundaries
    \item mod 4: Ensures discrete quarter representation
\end{itemize}

This creates a clean mapping between financial periods and quantum states:

\begin{equation}
\begin{cases}
```

```latex
    Q = 0 \mapsto \ket{00} \\
    Q = 1 \mapsto \ket{01} \\
    Q = 2 \mapsto \ket{10} \\
    Q = 3 \mapsto \ket{11}
\end{cases}
\end{equation}

\section{Implications for Physics and Mathematics}

Recognizing the geometric nature of time and the existence of an imaginary
temporal dimension could have significant consequences across various fields:

\begin{itemize}
    \item In physics, it may offer new insights into the nature of spacetime,
potentially impacting theories of relativity and quantum mechanics. The
imaginary temporal index could be related to concepts like imaginary time or
the complex plane used in some physical theories.
    \item In mathematics, incorporating an imaginary index extends the
traditional framework of linear algebra and vector spaces. It may lead to
novel geometric and algebraic structures that better capture the cyclical
aspects of time.
    \item For computation and data structures, acknowledging the need for an
extra index to fully represent cyclical patterns could inspire new algorithms
and optimizations. It highlights the importance of boundary conditions and the
special handling required when transitioning between cycles.
\end{itemize}

\section{Conclusion}

The observation that time behaves as a geometric curve with an additional
imaginary index challenges our conventional linear conception of time. It
opens up new avenues for exploration and research, both in understanding the
fundamental nature of time itself and in applying this insight to practical
problems across science and engineering.

By embracing the geometric complexity of time, including its imaginary
component, we may unlock new ways of representing, analyzing, and harnessing
temporal patterns. This could lead to breakthroughs in fields ranging from
physics and mathematics to computing and beyond.

As we continue to investigate the implications of this geometric perspective
on time, it is crucial to remain open to the potential for radical revisions
to our foundational theories and models. The imaginary index may be the key to
resolving long-standing puzzles and paradoxes, offering a more complete and
coherent understanding of the nature of time and its role in the universe.
```

```
\end{document}```
```