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Mathematics-Guided Tai-Chi Movements

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Abstract: Tai-Chi (also spelled Taiji or Taijiquan), the ancient Chinese martial art rooted in Taoist philosophy, emphasizes harmony, balance, and continuous motion embedded with mathematical geometric shapes. This work explores the rich intersections between Tai-Chi principles and mathematical structures such as the Lo Shu Magic Square, Fibonacci numbers, Golden Ratio, Lambdoma harmonics, and geometric forms like spirals and circles. We propose a novel framework for mathematicsguided Tai-Chi practice, demonstrating how mathematical concepts can inform movement design, enhance body awareness, and deepen meditative engagement. Drawing on empirical case studies and theoretical analysis, we illustrate how integrating these principles offers new pathways for physical training, cognitive enrichment, and interdisciplinary education. This synthesis invites a new image of Tai-Chi as both a somatic art and a living model of mathematical harmony.

While practicing Tai-Chi movements, Tao's thoughts, mathematical patterns, and body movements come together in harmony, and a mathematical expression for Tai-Chi motion shows up as a symbolic interconnected multi-integral of body motion (Ti-体), Breath Energy (Qi-气), and Mind Intention (Yi-意) differentiated over time t (时间) from 0 to ∞:

$$\text{Tai-Chi Motion} = \iiint [(\text{Body Motion-体}) + (\text{Breath Energy-气}) + (\text{Mind Intention-意})]\partial \text{Time}$$

This conceptual formula connects body mass, breath energy, and mind intention of three-inner harmonious state potentials as ONE Tai-Chi Circle (Figure 1).

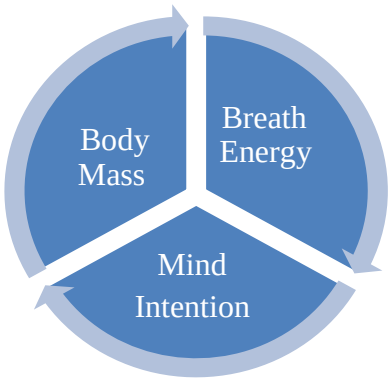

Figure 1. Tai-Chi Motion Unity

Leads to the primary purpose of this mathematical framework for further understanding the Tai-Chi motions and its teaching and learning.

1. To establish the connections between Tai-Chi motions and mathematics forms and functions to further scientific investigations on biological and psychological aspects of Tai-Chi motions.
2. To illustrate geometric shapes and forms of Tai-Chi motions to further

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improve effectiveness and perfections of Tai-Chi teaching and learning.
3. To transform Tai-Chi motions into mathematical numbers and geometric shapes to further visualize the thought patterns of Tai-Chi motions.

This work is intended for an audience of intellectually curious professionals, Tai-Chi practitioners, researchers, and should appeal both to the novice and the expert. This work can also serve as a short course for teaching and learning Tai-Chi as a living art and science.

Keywords: Tai-Chi Motion, Mathematical Embodiment, Lo Shu Magic Square, Fibonacci Sequence, Golden Ratio (φ), Lambdoma Harmonics, Circles and Spirals, Tai-Chi Teaching and Learning.

Tracing Brief History, Philosophy, and Geometry of Tai-Chi

Tai-Chi is a profound Chinese martial art known for its graceful, flowing movements and deep-rooted spiritual and philosophical underpinnings. Originating centuries ago, Tai-Chi embodies a unique fusion of history, philosophy, and geometry—an interconnection that defines its practice and purpose. Through its slow, deliberate motions, Tai-Chi offers insight not only into the martial traditions of China but also into the way humans relate to nature, time, and space.

Historical Foundations of Tai-Chi

Tai-Chi's origins are traditionally traced to the Chen family village in Henan Province, China, during the 17th century. However, some oral traditions and historical documents suggest that Tai-Chi has even older roots, possibly going back to the legendary Taoist sage Zhang Sanfeng during the Song Dynasty (960–1279). According to legend, Zhang developed Tai-Chi after witnessing a battle between a snake and a crane, marveling at the balance of softness and strength.

In more verifiable history, Tai-Chi was systematized and passed down through different family lineages, most notably the Chen(陈), Yan(杨), Wu(武), Wu(吴), and Sun(孙) styles. Each style preserved the core principles of Tai-Chi while offering unique interpretations of its movements and applications. Over time, Tai-Chi evolved from a martial art to a widespread form of physical and mental wellness, embraced for its health benefits and meditative qualities.

Philosophy: Yin, Yang, and Taoist Thought

The philosophical foundation of Tai-Chi is deeply rooted in Taoism and the ancient Chinese concept of yin and yang (Figure 2)- the dual forces that represent complementary opposites in the universe. Yin is associated with softness, stillness, and receptivity, yang with hardness, movement, and action. In Tai-Chi, practitioners aim to harmonize these forces within themselves through controlled motion and mental focus.

Figure 2. Yin-Yang Symbol depicting the foundational philosophy of Tai-Chi

Taoist philosophy emphasizes the concept of wu wei (non-action or effortless action), which is reflected in the fluid transitions of Tai-Chi forms. Movements are performed with minimal tension and maximum awareness, encouraging the practitioner to

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flow with rather than resist natural forces. The Dao-De Ching, attributed to Laozi, teaches that true strength comes from yielding and that the soft can overcome the hard—core principles seen throughout Tai-Chi practice. The DaoDe Ching by Laozi and the I-Ching (Book of Changes) have been influential texts in shaping Tai-Chi's philosophical underpinnings (Needham, 1956; Cohen, 1997).

Tai-Chi also embodies the Confucian ideals of discipline, harmony, and respect for tradition. While Taoism contributes the spiritual and metaphysical essence, Confucianism provides a moral and social framework for practice and transmission.

Geometry in Motion: The Spatial Intelligence of Tai-Chi

Tai-Chi is not only philosophical and historical but also geometrically intricate. Every movement in Tai-Chi can be analyzed through geometric patterns, spatial awareness, and body alignment. Practitioners move in circular and spiral patterns, tracing arcs, spheres, and spirals with their limbs and torso. These geometrical shapes are not arbitrary; they are designed to maximize energy efficiency, maintain balance, and channel internal force (qi or chi).

Circular Motion is fundamental in Tai-Chi (see Figure 3). Unlike linear martial arts that focus on direct force, Tai-Chi uses arcs and curves to redirect an opponent's energy and to maintain continuous motion. The circle represents completeness, unity, and the cyclical nature of life—all core themes in Taoist thought. Essential Tai-

Chi motion can be also illustrated with the simple circular shape (x2+y2=1) and its projection to a line segment of [0, 1] ([Yin, Yang]).

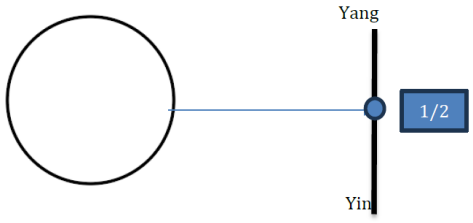

Figure 3. Dynamic Tai-Chi Circular Motion of Yin-Yang

This mathematical figure shows that Tai-Chi's motions in a form endless cycle between Yin and Yang.

Spiraling Movements are also significant, particularly in the Chen style, which uses silk-reeling energy (纏絲功, chán sī gōng). This spiraling energy mimics the unwinding of silk from a cocoon and is intended to generate internal power without muscular force. The human spine is located at the center of the human body. Tai-Chi's motion to all directions is generated from the central axis. Tai-Chi breathing motions of inhale and exhale receive, store, deliver energy through Yin-Yang exchange in a circular and spiral shape. One of spiral geometric shapes is illustrated in Figure 4 below.

Figure 4. Tai-Chi Spiral Motions of Yin-Yang

The spiral motion directions can be either clockwise or counter clockwise.

Body alignment and structure follow a vertical axis that connects heaven and earth, reflecting a microcosmic connection between the practitioner and the cosmos. This upright axis ensures stability while enabling free flow of energy, anchoring

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movements in a precise, almost architectural frame. Tai-Chi motion alignment and structure can be illustrated as in Figure 5.

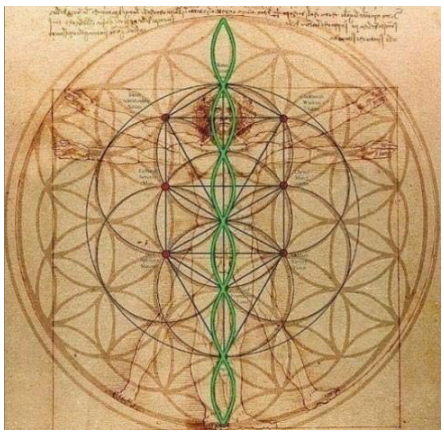

Figure 5. Geometry of Tai-Chi Motions

Next, we describe the general **geometry** of Tai-Chi's hand and foot fundamental movements for its practical access as teaching and learning foundation. Tai-Chi's 8 fundamental hand movements—also known as the "Ba Men" (八门) or Eight Gates—are core principles in traditional Tai -Chi practice. They are often studied along with the Five Steps (五步) as the "13 Postures" (十三势) which form the foundation of most Tai-Chi forms. They reflect energy pathways and body alignments. However, each also has a distinctive geometric shape or spatial direction that can be described in relation to the practitioner's body and intention. These movements are foundational for learning balance, flow, and the Yin-Yang principles inherent in Tai-Chi practice. The foundation of all movements starts at the opening form (also called **commencement**) and ends at closing form to return to the stillness.

Opening Form (Commencement: 起势, Qǐshì,)

The **Tai Chi opening posture** is a foundational stance that sets the tone for the rest of the form. Its geometry involves a combination of body alignment, weight distribution, and spatial awareness. Here's a detailed description of its geometry:

Feet and Leg Geometry

Feet Position: Begin with feet shoulder-width apart (roughly parallel), or in some styles, with the heels together and toes slightly turned out (~45°).

Legs: Knees are slightly bent — not locked, but relaxed — to create a rooted feeling.

Weight Distribution: Initially balanced evenly between both legs (50/50), allowing for control and readiness to shift.

Spine and Torso Alignment

Spine: Held upright, with the tailbone gently tucked under. The spine should feel suspended from the crown of the head, promoting a feeling of vertical lift.

Pelvis: Neutral, not tilted forward or backward.

Chest: Relaxed (not puffed out), often described as "hollowing the chest" (含胸, hán xiōng).

Back: Slightly rounded in the upper section (拔背, bá bèi) to promote energy circulation and structural integrity.

Shoulders and Arms

- **Shoulders**: Relaxed and slightly dropped, not lifted.
- **Arms**: Initially hang naturally by the sides. As the posture begins, arms

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raise in a gentle arc to about shoulder height, then descend — like floating and sinking — in a circular, wave-like motion.

• **Elbows**: Softly bent, hanging naturally. Not locked or stiff.

• **Hands**: Fingers relaxed, slightly apart. Palms face downward when rising, and turn slightly inward and downward when sinking.

Head and Gaze

• **Head**: Upright, as if suspended from above by a thread at the crown (顶头悬, dǐng tóu xuán).

• **Chin**: Slightly tucked to lengthen the back of the neck.

• **Gaze**: Soft, forward-looking, not focused sharply. The eyes follow the movement calmly and naturally.

Energetic Geometry (Internal Aspects)

• **Rootedness**: A strong connection with the ground through the feet (especially the **Yongquan** (涌泉)point on the soles).

• **Lift**: A counterbalancing upward force through the crown.

• **Peng Energy**: Even in the opening posture, there is subtle expansive energy in the limbs, called **peng jin (掤劲)** — like holding a large, inflated ball.

Ward Off (Peng, 掤)

The Tai-Chi Ward-off posture is one of the fundamental movements in Tai-Chi, often used as a defensive and balancing gesture: a fundamental defensive move that deflects incoming force, often involves an upward and outward circular motion of the arms and represents **yang energy**—expanding and buoyant. Geometry of the Ward-off Posture is briefly described below:

Body Alignment

• The body is slightly turned sideways, so one shoulder leads while the other trails.

• The spine is straight but relaxed, maintaining an upright posture.

• The hips and feet align with the body's turn, typically at about a 45degree angle to the front.

Feet and Legs

• Feet are roughly shoulder-width apart or slightly wider.

• Weight is evenly distributed or slightly shifted toward the rear leg for stability.

• The knees are slightly bent to maintain balance and readiness.

Arms and Hands

• One arm (usually the leading side) is raised in front, with the palm open and facing outward, roughly at chest or shoulder height.

• The elbow of this arm is slightly bent but firm, creating a soft "guarding" shape as if warding off an incoming force.

• The other arm is positioned near the waist or lower abdomen, with palm facing inward or downward, ready for the next movement or balance.

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Head and Eyes

- The head remains upright and aligned with the spine.
- Eyes focus gently forward, in the direction of the leading arm, maintaining awareness.

Energy and Intention (Qi)

The posture embodies a spiral or circular energy, with the arm and torso coiling slightly, generating a flowing defensive force rather than a rigid block.

Roll Back (Lu, 捋)

The Roll Back posture is often used to neutralize and redirect incoming force by yielding rather than meeting it head-on: a receptive move that redirects an opponent's force away from the center, typically involves a soft, spiraling backward motion and expresses **yin energy**—yielding and absorbing. Geometry of the Roll Back Posture is briefly described below:

Body Alignment

- The torso rotates gently away from the incoming force, creating a slight twist in the waist.
- The body leans or shifts backward slightly, using the waist and hips to absorb and redirect energy.
- The spine remains straight but relaxed, maintaining good posture.

Feet and Legs

- Feet are about shoulder-width apart or a little wider.
- Weight shifts mostly to the rear leg (about 60-70%), with the front leg lighter and ready to move or pivot.
- Knees stay slightly bent to keep a stable and flexible stance.

Arms and Hands

- The leading hand extends forward but with a relaxed, pulling motion rather than pushing.
- The palm faces inward or slightly upward, as if "rolling back" an opponent's force.
- The other hand stays near the waist or lower abdomen, palm up or inward, poised to follow up or maintain balance.

Head and Eyes

- Head stays upright, aligned with the spine.
- Eyes remain focused on the opponent or the direction of the incoming force.

Energy and Intention (Qi)

- The posture emphasizes yielding and redirection, with a soft, circular motion that "rolls" the force off-center.
- The body moves as a connected whole, with the waist and arms flowing in harmony.

The Roll Back posture looks like a gentle pulling or "drawing back" motion, allowing the opponent's energy to pass by or be guided aside rather than blocked directly.

Press (Ji, 擠)

The Press posture combines the force of both hands to push forward and often performed after Ward Off and Roll Back in sequence. It represents the **interplay of Yin and Yang**, merging into focused

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power. Geometrically, this posture embodies symmetrical curves, inward grounding, and outward spiraling energy. Here's how to describe it using spatial and geometric language:

Basic Geometry of the Body

Stance (Lower Body):

- Usually in a bow stance (one foot forward, one back), like the "Pluck" posture.
- Front knee is bent roughly 90–100°, centered over the foot.
- Back leg is extended at an angle of 120–150° at the knee.
- Weight distribution: ~60–70% on the front leg.

Feet:

- Front foot points forward; back foot turned out ~45°.
- Heels form a diagonal line, creating a long triangular base.

Torso and Spine

- Spine is vertical, straight (not leaning), with a slight sinking feel.
- Torso is turned slightly diagonally forward, not square to the front.
- Shoulders are dropped and rounded forward slightly.

Arms and Hands Geometry

Arm Position:

- Both arms extend forward from the shoulders in a soft arc, not fully straight.
- Elbows are bent at ~135–150°, hands slightly separated (shoulderwidth or narrower).

Hand Position (Ji / Press):

- Hands form a small triangle or diamond shape:
  - Palms face slightly inward or toward the opponent.
  - One hand supports the base of the opposite wrist.
  - The press emerges from the coordination of the rear hand pressing through the front hand.

Force and Line Geometry

Energy flow forms a spiral vector:

- From the back foot, spiraling through the Dantian, and directed through both hands.
- The hands create a compression/expansion shape, like the outward pressure from a compressed spring.
- The press itself projects a force vector forward and slightly upward, along with the diagonal of the bow stance.

Symmetry and Structure

- Symmetrical arc from shoulder to hand.
- A parabolic tension is held between the elbows and wrists.
- The center of mass lies equidistant between the feet, centered but projected forward.

Visual Analogy

- Your arms forming the shape of a bow about to release an arrow.
- The press action sends that arrow straight along a diagonal line,

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supported by a coiled spring beneath (your back leg and waist).

Push (An, 按)

The Push posture is a strong, stable forward push with both palms. Following the Press in traditional sequences, it symbolizes direct and grounded force. Geometrically, it represents expansion through alignment and rooted power, rather than brute force. Here's a detailed breakdown of its geometry:

Stance (Lower Body Geometry)

Legs and Feet:

- Typically, in a bow stance:
  - Front foot forward, pointing straight.
  - Back foot turned out ~45°, forming a stable triangular base.
  - Weight is distributed 60–70% on the rear leg before the push, then shifts forward during the push.

Geometric Shape:

- The lower body forms a wedge or isosceles triangle, stable and grounded.
- The base line between the feet provides anchoring for forward energy.

Torso and Alignment

- The spine is upright and aligned vertically, with a slight forward tilt from the Dantian.
- Torso is centered, facing forward or slightly turned toward the front knee.
- The hips are squared or slightly turned depending on the style.

Arms and Hands Geometry

Arm Position:

- Arms extend forward in two gentle arcs, like hugging a tree or holding a large ball.
- Elbows are bent (~135–150°), with wrists slightly lower than shoulders.

Hand Position (An / Push):

- Palms are facing outward, fingers pointing up or slightly outward.
- Hands are shoulder-width apart, usually parallelor slightly converging.
- The hands push in a spiraling forward and downward path, not a straight line.

Energy and Force Vectors

Energy flows from:

  - Feet → legs → waist → spine → arms → palms.

- The push isn't linear, it’s a spiral force projected outward, like compressing a spring and releasing it.

Visual Geometry:

- Think of a compressed ellipse that suddenly elongates.
- Force vector is forward and slightly downward (not straight ahead like a shove).

Structural Shapes

- Arms form a partial circle or arc (C-shape) from shoulder to fingertip.
- The triangle formed between:

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- Left hand, right hand, and Dantian (center of the body) creates the force-triangle of projection.
- The whole body forms a dynamic wedge: base at the feet, apex at the hands.

Table 1. Key Angles & Alignment

Part	Angle/Alignment
Front knee	~90°
Back leg	~120–150°, angled ~45° outward
Elbows	~135°
Arms	Forward arc, forming ~45° from torso axis
Spine	Vertical with forward root

Visual Metaphor

Imagine pushing a heavy door with both palms, but instead of leaning, your whole-body coils and expands into the movement. The geometry is about balance, spiraling force, and aligned projection, not brute pressure.

Pull Down or Pluck (Cai, 採)

The Pull Down or Pluck posture is a quick, downward force that draws an opponent off balance. It often targets the arm or shoulder and uses sudden yin force to control.

Geometric Structure:

Stance:

Typically, in a bow stance (gong bu), where one foot is forward (usually the left) and the back foot is angled outward. o The front knee is bent, aligned vertically over the toes. o Back leg is straight but not locked, forming a roughly 120–150° angle at the knee.

Upper Body:

Spine:

- Erect and slightly sunk (think of a string pulling the crown of the head up while the tailbone drops).
- Shoulders are relaxed and slightly rounded forward.

Arms:

Lead hand (usually the left) is extended forward, elbow bent at roughly 135°, palm facing inward or slightly downward depending on style. o Rear hand (usually the right) supports behind or underneath, also bent, with the elbow lower than the wrist. Hands form a kind of curved bridge or elliptical arc.

Hands:

- Fingers are naturally spread and gently curved — not stiff.
- The energy pathway follows a spiral from the rear hand (Dantian area) outward through the lead hand.
- The hands mimic the action of "grasping and pulling silk" both extending and drawing inward at once.

Weight Distribution:

- About 60-70% of weight on the front leg.
- The back leg anchors and provide stability.

Lines and Planes:

- The torso and hips face 45° from the front foot direction — not square, not sideways.

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- The hands and arms form a soft curved plane, like a crescent or arc between the arms.
- The movement expresses a diagonal force vector — energy travels diagonally from the back foot through the torso to the front hand.

Shapes & Angles:

- Body posture resembles a dynamic triangle between the two feet and the center of gravity (Dantian).
- Arms form an elliptical loop or C-shape.
- The posture captures yielding and redirecting — visually expressed as curved lines and coiled spirals rather than straight force lines.

Split (Lie, 挒)

The Split posture is a spiraling motion that pulls in opposite directions. It combines rotational yin and yang forces. It's applied to disrupt the opponent's center through torque. It is a dynamic and expressive movement that embodies the energy of tearing or rending apart, using coordinated oppositional forces. Geometrically, it represents spirals and vectors moving in opposite directions from a centered base. Here's how to describe its geometry:

Stance and Lower Body Geometry

Legs and Feet:

- Often performed in a wide stance, either:
    - Bow stance (one foot forward) or o Horse stance (both feet parallel and wide apart).
- Weight is more evenly distributed or slightly favoring one leg.

Angles:

- Knees bent ~90–110°, forming a strong triangular base.
- Feet form a base line, creating an isosceles or scalene triangle with the center of gravity.

Torso and Alignment

- Spine is vertical or slightly turned.
- Torso faces forward or slightly diagonal depending on the split direction.
- Core is centered and sunken (lowered Dantian) for stability. 3. Arms and Force Geometry

Arm Movement:

Arms move in opposite directions:

- One arm pushes or slices forward.
- The other pulls or redirects backward/downward.

Geometric Forces:

- This creates a two-point vector radiating away from the center.
- The arms form a diagonal line or arc—like pulling apart a long elastic band.

Energy and Force Vectors

- The essence of "Split" is oppositional spiral force:
    - The body is rooted in the center while energy splits outward. o This action mimics twisting and stretching—like wringing out a towel.

Force Path:

- From the rear foot through waist and spine, out to both hands in opposing directions.

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- Energy flows along a rotational axis, often on a diagonal plane.

Table 2. Structural Geometry Summary

Element	Geometric Description
Legs/Feet	Triangle base, wide and grounded
Spine/Torso	Vertical axis or slight diagonal lean
Arms	Diagonal line or arc moving in opposition
Energy Vectors	Two arrows radiating outward from the core
Body Shape	X or "open bowstring" under tension

Visual Metaphor

- You're pulling apart a giant elastic band with both hands.
- Your feet are planted firmly as if splitting a tree trunk with your entire body.
- Your torso stays centered, but your limbs spiral and extend in opposite directions.

Elbow Strike (Zhou, 肘)

This is a compact, spiraling movement where power is delivered through the elbow instead of the hand. Geometrically, it focuses on short-range, coiled force, angular alignment, and structural compression. It's often used in close contact when hands are obstructed. It delivers **focused yang energy** in a compact form. Its geometry is described below:

Stance & Lower Body Geometry

Legs and Feet:

- Usually in a short bow stance or empty stance:
  - One leg bent (front), bearing most of the weight.
  - Rear leg slightly behind, angled outward for balance.
- Feet form a narrow triangle or L-shape, providing rootedness.

Angles:

- The front knee bent at ~90°.
- Rear leg bent or extended at ~120–140° depending on the style.
- Feet are spaced roughly hip-width or slightly narrower.

Torso and Axis

- The torso is rotated toward the direction of the elbow strike.
- The spine is upright but coiled, turning from the waist and Dantian.
- The torso and hips are not square; they are in a twisted, spring-loaded configuration.

Arms and Elbow Geometry

Striking Arm:

- The striking elbow is bent at ~90–120°, kept close to the body.

The forearm is angled downward or horizontal, depending on whether the elbow strike goes forward, to the side, or downward.

Supporting Arm:

- The other hand usually pulls inward or crosses the chest, sometimes protecting the centerline.

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- This arm may form a compressed diagonal line with the striking arm.

Key Geometric Shape:

- Arms form a folded spiral, resembling a coil or "hooked wing".

Energy and Force Vectors

- The strike originates from the ground, spiraling through the leg, hip, waist, and torso into the elbow.
- The energy path follows a compressed arc, projecting force through the point of the elbow.

Force Geometry:

- Unlike a long reach (press or push), this is a short explosive arc, like the release of a spring.
- The elbow becomes the tip of a lever—the fulcrum being the rotating spine and grounded rear leg.

Table 3. Structural Geometry

Element	Geometric Description
Lower Body	Triangular base, narrow but stable
Spine	Vertical, with rotational torque
Arms	Bent at ~90–120°, forming a compressed spiral
Elbow Force Line	Curved arc from rear foot → waist → elbow
Overall Shape	Compact spiral or bent bowstring under tension

Visual Metaphor

You're coiling a spring by turning your waist and keeping your elbow tight to your body.

- Then, you release that coil directly into a target that's close—like ramming your elbow into a door right beside you without leaning.

Shoulder Strike (Kao, 靠)

The Shoulder Strike posture is a powerful strike or push using the body's shoulder and torso. It's used to break through or disrupt an opponent's guard. It represents whole-body power aligned with intention. Its geometry focuses on alignment, compression, rotation, and unified forward projection. Here's a detailed breakdown of the structural and geometric aspects:

Stance and Lower Body Geometry

Legs and Feet:

- Typically, in a short bow stance or diagonal step-in:
  - Front leg bent at about 90–100°.
  - Rear leg supports and drives the motion, angled outward ~45°.

Geometric Base:

- Feet form a triangular base or asymmetrical wedge.
- Hips and knees aligned to support a forward-driving motion.

Torso and Spine

- The torso leans forward and into the strike but not hunched.
- Spine remains erect and slightly rotated—delivering force through the torso-to-shoulder vector.
- The rotation originates in the waist (Dantian) and spirals outward. 3. Shoulder and Arm Geometry

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Striking Side:

- The striking shoulder is driven forward along with the torso.
- Arm on the striking side is either:
  - Slightly bent and lowered (to keep elbow from obstructing), or o Pulled slightly back to emphasize shoulder projection.

Non-striking Arm:

- Usually raised or extended diagonally, acting as a guard or counterbalance.
- It may also be used to control or deflect the opponent.
  - Geometric Configuration:
- Arms and shoulders form a C-shape or offset X, showing rotational energy.
- Shoulders aligned like a battering ram, body behind the shoulder.

Energy and Force Vectors

Energy path:

- Rear foot → leg → waist → spine → shoulder.
- The shoulder becomes the point of contact—but the true driving force is from the whole body behind it.

Vector Geometry:

- The force vector is a short-range, forward-spiraling arc.
- Not a linear push—it's a curved, body-driven collision path.

Table 4. Structural Summary Table

Element	Geometric Description
Legs/Feet	Triangle/wedge-shaped base, forward directed
Spine/Torso	Vertical axis tilted forward, rotated from waist
Shoulders	Forward projected; hips and shoulders aligned
Arms	Asymmetric arc (striking arm bent or back; other up)
Force Vector	Forward spiraling arc with shoulder as contact point

Visual Metaphor

- You're driving your shoulder into a heavy door, with your entire body behind it.
- One arm guards or deflects, the other side of your body funnels momentum into the shoulder like a wedge.

Closing Posture (收勢, Shōushì)

The Tai-Chi closing postures is the mirror of the opening form and brings the practice to a calm, centered conclusion. Geometrically and energetically, it expresses a return to stillness, balance, and integration. Here's a breakdown of its geometry:

Feet and Leg Geometry

- Feet Position: Feet end up shoulder-width apart, as in the beginning. Some styles may end with the feet together, depending on the form.

Weight Distribution:

As the movement transitions, weigh is often shifted to one leg (typically the right), then back to center for a balanced finish.

Final posture usually ends with even weight distribution (50/50).

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- Legs: Knees remain softly bent, never locked. They track over the toes, keeping alignment.

Spine and Torso Alignment

- Spine: Stays vertically aligned, upright but relaxed.
- Tailbone: Slightly tucked.
- Chest and Back: Chest relaxed (sunken slightly inward), upper back gently rounded.

Shoulders, Arms, and Hands

Shoulders: Remain relaxed and down.

Arms:

- From the final movement (e.g., a push), the arms lower smoothly in an arc from shoulder level to the sides. o Hands pass through a "holding a ball" shape in front of the torso (palms inward), then slowly descend.
- Elbows drop gently, never flaring outward.

Hands:

Palms face the ground or slightly inward as they descend. o Fingers stay relaxed and slightly apart. o Hands naturally return to the sides or in front of the lower abdomen (depending on style).

Head and Gaze

Head: Upright, suspended from the crown.

Gaze: Softly focused forward or downward, symbolizing calm awareness.

Breath and Energy (Internal Geometry)

Breathing: Slows down naturally, often synchronized with the arm descent.

Inhale during arm lift (if present), exhale as hands descend.

Energetics:

- Qi is said to settle into the Dantian (丹田, the energy center below the navel).
- The movement emphasizes rooting downward and releasing tension.
- There's a sense of gathering and storing all cultivated energy.

The closing posture is a mirror of the opening, but now with a feeling of completion and return:

- Symmetrical structure
- Vertical alignment
- Descending arcs and arms
- Setting energy into a centered, grounded base

It embodies the Tai-Chi principle of returning to stillness after motion: “motion rooted in stillness, and stillness rooted in motion.”

The “Five Steps” (五步, wǔ bù) in Tai-Chi represent fundamental directions of footwork that embody spatial awareness and strategic positioning. These steps form a geometric foundation for movement, balance, and energy flow in all traditional Tai-Chi styles, particularly in the Tai-Chi Classics and Yang-style Tai-Chi theory.

Overview of the Five Steps (五步 Wǔ Bù)

1. The Five Steps correspond to cardinal and diagonal directions and are often interpreted as follows:
2. Jìn bù (進步) – Advancing / Forward Step Tuì bù (退步) – Retreating / Backward Step
3. Zuo gù (左顧) – Looking Left / Left Step
4. You pàn (右盼) – Looking Right / Right Step
5. Zhōng dìng (中定) – Central Equilibrium / Stable Center

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Each movement has spatial, structural, and energetic implications, which we can analyze geometrically.

Advancing (進步 / Forward Step)

- Geometry: A linear forward projection from the body's center of gravity.
- Line: Straight line forward, parallel to the sagittal plane.
- Purpose: Expands distance to control or approach an opponent; symbolically associated with growth or assertion.
- Body Mechanics: The weight transitions from the rear to the front leg while maintaining alignment over the central axis.

Retreating (退步 / Backward Step)

- Geometry: A linear backward projection, often with a slight curve to keep vision on the opponent.
- Line: Reverse of the advancing line; again along the sagittal plane.
- Purpose: To evade, absorb, or redirect incoming force.
- Body Mechanics: Requires strong root and control to maintain balance and avoid collapse in the structure.

Left Step (左顧)

- Geometry: Movement laterally along the coronal plane, typically forming a 90-degree angle from the original stance.
- Line: Perpendicular to forward-backward line.
- Purpose: To reposition relative to an opponent or angle the body for power generation.
- Energetic Aspect: The body spirals slightly to support coiling and uncoiling energy.

Right Step (右盼)

- Geometry: Mirroring the left step; movement rightward along the coronal plane.
- Line: 90-degree angle to the sagittal plane in the opposite direction.
- Use: Balancing lateral mobility, offering symmetry in movement design.
- Strategy: Allows for flanking, evading, or circling around an opponent.

Central Equilibrium (中定)

- Geometry: Represents a point or axis—the origin from which all steps radiate.
- Shape: Can be imagined as the center of a circle or the pivot point of a compass.
- Purpose: Embodies stillness, stability, and readiness. It's the fulcrum around which all other directions move.
- Symbolic Geometry: Think of a circle with radiating spokes—the practitioner stands at the center, balanced and aware of all directions.

Spatial and Energetic Implications

- The geometry of the Five Steps teaches 3D spatial awareness—not just flat steps, but depth, balance, and turning.
- Practitioners learn to transition weight smoothly, keeping the vertical central axis (zhong ding) always aligned.
- This geometric discipline builds internal balance (rooting) and external adaptability, which are critical for both martial applications and health benefits.

The Five Steps in Tai-Chi offer a beautifully geometric view of how the human body moves with balance, intention,

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and awareness. They form a living compass, with each step acting like a vector controlled by a central pivot, enabling practitioners to adapt gracefully to any direction or force.

Tai-Chi as Living Art and Science

Tai-Chi is more than a martial art or a fitness routine; it is a living synthesis of history, philosophy, and geometry. Its origins tell a story of cultural preservation and transformation. Its philosophy reveals a path to balance, peace, and inner strength. Its geometry teaches us the elegance of motion, spatial harmony, and embodied intelligence.

As both a practical discipline and a metaphor for life, Tai-Chi continues to evolve and inspire across cultures. Whether practiced for self-defense, health, or spiritual growth, Tai-Chi invites practitioners into a deeper conversation with the self, the body geometric shapes, and the world of energy.

Embracing The Harmony of Math and Tai-Chi Movements

The Harmony of Math and Tai-Chi Movement

At first glance, mathematics and Tai-Chi seem to belong to entirely different realms—one rooted in logic and abstraction, the other in physical movement and inner harmony. Yet, beneath their surface differences lies a shared foundation built upon patterns, balance, and precise structure. Mathematics offers a language to understand the world in terms of numbers and relationships, while Tai-Chi embodies these relationships through flowing motion, symmetry, and energy control. The intersection of math and Tai-Chi reveals that physical practice can be an expression of mathematical beauty, and that understanding this connection can deepen both intellectual and physical pursuits.

One of the most fundamental mathematical concepts present in Tai-Chi is symmetry. In math, symmetry describes objects or systems that remain unchanged under certain transformations—rotations, reflections, or translations. Similarly, Tai - Chi routines, or “forms,” often include mirrored movements, rotations, and carefully balanced sequences that promote equilibrium in the body. For instance, a movement performed to the left is often countered by a movement to the right, achieving a physical symmetry that mirrors mathematical balance.

In Tai-Chi, the Dantian (丹田) is a central concept in traditional Chinese martial arts, medicine, and Daoist practices. It refers to an energy center in the body where qi (氣)—the vital life forces cultivated, stored, and circulated. We can use the mathematical concept of "unity of roots" metaphorically to describe Tai-Chi's Dantian, especially in a philosophical or symbolic way.

In algebra, roots of unity are uniformly distributed on the circumference of the unit circle. It decodes the equation zn-1=0. The roots or zeros of unity of two opposite equations contain the powerful states that generate something new, and sparks fire off. These roots lie evenly on the unit circle in the complex plane, all equidistant from the origin, radiating out from a single central point (the number 1 at 0∘) as illustrated in Figure 6.

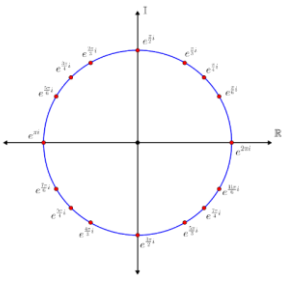

Figure 6. Roots of Unity

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Let's consider how this map to Tai-Chi and the Dantian:

Central Origin of Movement

- Just as roots of unity radiate symmetrically from a central point (the origin),
- In Tai-Chi, all movement and energy radiate from the lower Dantian, the core of physical and energetic balance.

Unity and Balance

- Roots of unity are in harmony, forming a complete circle—a symbol of balance and wholeness.
- The Dantian is the center of internal harmony, from which breath, energy, and motion must flow evenly in all directions.

Cyclic Nature

- Roots of unity repeat in cycles (every 2π), reflecting circularity and continuity.
- Tai Chi movements are circular, continuous, and flowing, mirroring this cyclical nature.

Multiplicative Identity

- Mathematically, multiplying a root of unity by itself cycles through other roots, always returning to 1—a return to the source.
- In Tai Chi, movement begins and ends in stillness centered in the Dantian—a return to the center after each form.

Table 5. Summary of the Analogy

Math (Roots of Unity)	**Tai Chi (Dantian)**
Centered on the origin	Centered on the lower Dantian
Balanced and symmetrical	Harmonious flow in all directions
Cyclical and repeating	Movements are flowing and continuous
Unified multiplicative system	Unity of body, breath, and energy

Geometric and Mathematical Rhythm of Tai-Chi

Another shared element is geometry (Skinner, 2004). Tai-Chi is deeply geometric: practitioners trace arcs, circles, spirals, and lines in space with their arms, legs, and center of gravity. These shapes are not accidental; they follow the natural pathways of the joints and muscles and are designed to optimize energy flow and structural efficiency. Circular motions—prevalent in both Tai Chi and mathematical modeling—represent continuity, unity, and flow. Even the placement of feet and angles of the knees during a stance can be analyzed using geometric principles to ensure stability and optimal posture.

In addition to geometry, mathematical rhythm and timing play a critical role in Tai-Chi. Much like in calculus, where the concept of limits and rates of change define motion, Tai-Chi emphasizes the continuous flow of movement. There are no abrupt starts or stops; transitions are smooth and calculated. Each motion has a pace, often measured in beats or breaths, which can be mathematically modeled. This rhythm introduces the idea of periodicity and pattern, both key concepts in mathematical analysis.

Moreover, Tai-Chi shares a kinship with systems theory and dynamics, branches of mathematics used to describe how systems change over time. Tai-Chi is, in essence, a dynamic system of the human body

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interacting with gravity, space, and internal energy (Qi). Movements are not isolated; they depend on previous positions and set the conditions for the next. This chain of dependent motion can be likened to a recursive function or a dynamic equation in math, where each output becomes the next input. Due to the scope of this work as a guide for Tai-Chi practice, here we only outline mathematical framework of the point of Dantian, each area can be further investigated to mathematical model the Dantian motion.

We'll treat Dantian as a mathematical and physical construct central to movement generation, internal force (Jin/劲), and energetic coherence.

Coordinate Systems and Geometry

Body-Centered Coordinate Frame

We define a local coordinate system with origin at the Lower Dantian:

- x= left-right (lateral)
- y= up-down (vertical)
- z= front-back (sagittal)

This reference frame enables us to model motion in 3D using transformation matrices.

Rotation and Kinematics

Rigid Body Rotation

- Let the torso rotate as a rigid body about the Dantian.
- Rotation vector: $\omega=(\omega_x,\omega_y,\omega_z)$
- Any point r (e.g. hand, elbow) relative to the Dantian has velocity:

$$v=\omega\times r$$

This gives the instantaneous velocity field of body parts relative to the Dantian.

Rotation Matrices

- Rotation about z-axis (waist turning):

$$R_z(\theta)=\begin{bmatrix}\cos\theta & -\sin\theta & 0\\ \sin\theta & \cos\theta & 0\\ 0 & 0 & 1\end{bmatrix}$$

Complex Tai Chi spirals require composed rotations about multiple axes:

$$R=R_x(\alpha)R_y(\beta)R_z(\gamma)$$

These are useful to simulate torso twisting, hip turning, and coordinated limb rotation around the Dantian.

These are useful to simulate torso twisting, hip turning, and coordinated limb rotation around the Dantian.

Angular Momentum and Torque

Angular Momentum

$$L=I\omega$$

I: Moment of inertia tensor (depends on mass distribution around the Dantian)

In Tai-Chi, Dantian is a rotational hub, and whole-body coordination affects the effective moment of inertia.

Torque Generated at the Dantian

$$\tau=dL/dt$$

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This governs how intention and effort (Yi and Jin) translate into motion. Tai-Chi emphasizes smooth, continuous torque from the Dantian rather than muscular force from extremities.

Spiral Dynamics and Helicoidal Motion

Tai-Chi's movement often follows spiral paths. These can be modeled using parametric equations.

3D Helix from the Dantian

A basic spiral path extending from the Dantian to a hand might be:

$$x(t)=r\cos(\omega t)$$

$$y(t)=r\sin(\omega t)$$

$$z(t)=kt$$

Where:

r: Radius of the spiral

ω: Rotational frequency

k: Vertical rise rate (differentiates “coiling upward” vs “downward” spirals)

This maps how force propagates spirally from the center out through the limbs.

Internal Energy (Qi) Modeling

From a modern physics/engineering lens, we might model Qi behavior near the Dantian using:

Potential Field Model

Let $\phi(r)$ be a scalar potential function centered at the Dantian. For spherical symmetry:

$$\phi(r)=Q/4\pi\varepsilon 0r$$

Where:

Q: Energetic "charge" at Dantian

$E=-\nabla\phi$: Energy flow or force field (analogy to electric field)

This simulates Qi radiating outward from the Dantian, affected by posture and breath.

Breathing and Harmonic Oscillation

The Dantian also pulsates subtly with Diaphragmatic Breathing, which can be modeled as a harmonic oscillator:

$$x(t)=A\cos(\omega t+\phi)$$

Where:

A: Amplitude of expansion/contraction

ω: Breathing frequency

Represents Dantian inflation/deflation as breath cycles move Qi

Advanced practice may invoke phase-locked oscillations between breathing, movement, and Dantian rotation.

Coupled Systems and Whole-Body Coordination

Model the body as a multi-body system coupled via joints and linked at the Dantian. The equations of motion become:

$$M(q)\ddot{q}+C(q,\dot{q})\dot{q}+G(q)=F$$

Where:

q: Generalized coordinates (joint angles)

M: Inertia matrix

C: Coriolis/centrifugal terms

G: Gravity

F: Force inputs, centered at the Dantian

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This models how subtle Dantian-initiated movements propagate mechanically and energetically through the rest of the body.

Here we summarize mathematical metaphors for Dantian

Table 6. Mathematical Metaphors for Dantian

Dantian Aspect	**Mathematical Tool**
Rotation center	Vector cross product, rotation matrices
Spiral motion	Parametric 3D helix
Qi flow	Scalar/vector fields, potential functions
Breathing	Harmonic oscillators
Full body motion	Coupled rigid-body dynamics
Force generation	Torque equations $\tau=I\alpha$
Stability	Lagrangian mechanics, equilibrium analysis

Harmony and Balance of Tai-Chi and Mathematics

Finally, both math and Tai-Chi emphasize the importance of internal consistency and balance. In mathematics, an elegant solution is one that is not only correct but also balanced and simple. In Tai-Chi, elegance arises from the internal harmony of breath, movement, and intention. Mastery in either discipline comes from understanding fundamental principles and applying them with precision and creativity.

Tai-Chi and mathematics are two languages through which we can explore and express the structure of reality. One is abstract, symbolic, and numerical; the other is physical, intuitive, and fluid. Yet both strive for a deeper understanding of harmony and balance. For practitioners and students of either field, recognizing these parallels can open new paths of insight—revealing that the logic of mathematics and the grace of Tai-Chi are not separate, but complementary forces. This work explores the rich intersection between Tai-Chi principles and mathematical structures such as the Lo Shu Magic Square, Fibonacci numbers, Golden Ratio, Lambdoma harmonics, and geometric forms like spirals and circles. We propose a novel framework for mathematics-guided Tai-Chi practice, demonstrating how mathematical concepts can inform movement design, enhance body awareness, and deepen meditative engagement.

Connecting Tai-Chi with Lo Shu Magic Square

Lo Shu Magic Square and Tai-Chi Motions

This section explores the interrelation between the Lo Shu Magic Square and Tai-Chi motions, analyzing their shared philosophical underpinnings in Chinese cosmology and metaphysics. By examining the numerical harmony of the Lo Shu and the dynamic balance of Tai-Chi movements, we demonstrate how these systems reflect foundational principles of Yin-Yang, the Five Elements (Wu Xing 五行), and Daoist thought. Ultimately, this section presents an integrated view of how abstract mathematical structures and bodily movement converge in traditional Chinese philosophy.

Origins and significance legend attributes the origin of the Lo Shu Square to a mythical turtle that emerged from the Luo

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River bearing a pattern on its shell (Figure 7), interpreted as the earliest magic square.

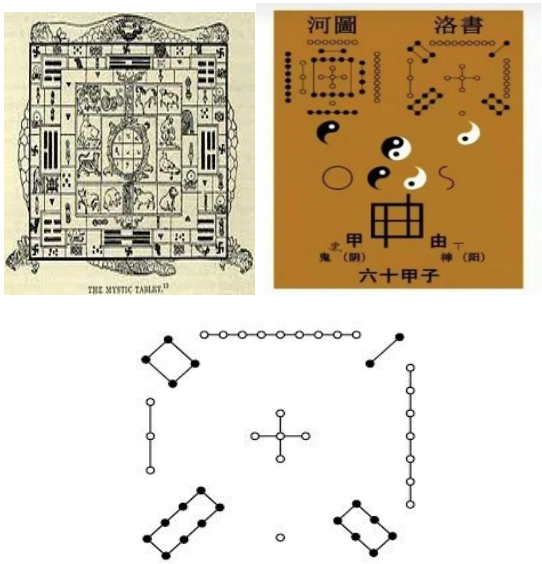

Figure 7. Luo River, Mythical Turtle, and Lo Shu Magic Square

The Lo Shu Magic Square is a 3x3 grid (Figure 8) in which numbers 1 to 9 are arranged so that the sum of each row, column, and diagonal equals 15. It holds a foundational place in Chinese mathematical and philosophical traditions.

4	9	2
3	5	7
8	1	6

Figure 8. Lo Shu Magic Square

In Chinese numerology, the central number 5 is symbolic of the center or equilibrium, flanked by pairs (e.g., 4 and 6, 2 and 8) that symbolize complementary forces. In modern linear algebra, Lo Shu square is a 3x3 matrix. Here we denote this matrix by $\mathbf{H}_{3x3}$. We'll further explore its mathematical properties associated with Tai-Chi motions.

The Lo Shu Square is traditionally associated with the Five Elements (Wood, Fire, Earth, Metal, Water), directions, and phases of transformation. Its symmetry and mathematical elegance made it an important tool in feng shui, astrology, and the Yi Ching (Book of Changes), serving as a model of balance and dynamic flow in the cosmos (Figure 9).

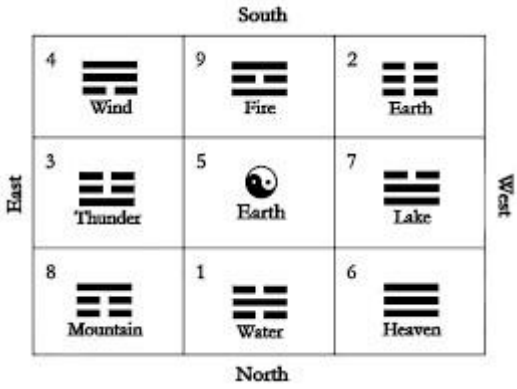

Figure 9. Lo Shu Magic Square Association with I-Ching and Five Elements

Tai-Chi, a form of internal martial art grounded in Daoist philosophy, emphasizes balance, circular motion, and the continuous transformation of energy. Although seemingly distinct disciplines—one numerical and static, the other physical and dynamic—they share a deep symbolic and conceptual linkage. Here we demonstrate how the structure of the Lo Shu Magic Square mirrors the cyclical and harmonious principles expressed in Tai-Chi motions, illustrating a profound unity between form and movement, abstraction and embodiment. Philosophy in Movement Tai-Chi, developed as both a martial art and a meditative practice, is grounded in the concept of Taiji, the Supreme Ultimate, which generates the dual forces of yin and yang. Tai-Chi movements are slow, continuous, and circular, emphasizing the

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cultivation and flow of qi (life energy) through the body. Each motion in Tai-Chi embodies principles of balance, rootedness, and the transformation of opposites, mirroring the dialectical nature of yin and yang. The sequence of movements often follows patterns that reflect cosmological principles. The body becomes a vessel through which the universe expresses its cyclical order. Practitioners of Tai-Chi are trained to sense subtle shifts in weight and energy, much as the ancient scholars discerned cosmic order through patterns such as the Lo Shu. Both the Lo Shu Square and Tai-Chi embody Daoist cosmology, especially the interplay of opposites and the dynamic equilibrium that characterizes the Dao. The arrangement of numbers in the Lo Shu reflects the balance of yin (even numbers) and yang (odd numbers), and their positioning in spatial symmetry. For example, the vertical and horizontal axes of the square correspond to cardinal directions, while the central 5 represents the Dao or Earth as the point of balance. A comprehensive exploration of the history and meaning of the Lo Shu square, tracing its origins and cultural significance can be found in [Swetz, 2002].

Similarly, Tai-Chi movements often begin and end in the central axis, moving outward and returning, much like the Lo Shu's flows of numerical balance. The circular energy patterns in Tai-Chi echo the rotational symmetry found in the square. Each Tai-Chi form or posture reflects an implicit geometry that can be analogized to the arrangement of numbers, guiding movement through space with a structure akin to the ordered harmony of the magic square.

Both the Lo Shu Square and Tai-Chi reflect Daoist cosmology (Cattoi, 2007, Chang, 2014), particularly the notion that the universe is a dynamic system of interrelated parts governed by the Dao, or the Way. The Lo Shu Square offers a numerical and symbolic matrix, while Tai-Chi provides kinesthetic realization of the same principles. Key points of intersection include:

- **Centrality and Balance**: The number 5 in the center of the Lo Shu corresponds to the central Dantian in Tai-Chi practice. Both symbolize the need to establish a stable center to coordinate movement and energy.
- **Movement in Stillness**: Although the Lo Shu appears static, its numbers suggest continual movement and transformation—a theme echoed in Tai-Chi's flowing motions that emerge from internal stillness.
- **Directional Correspondence**: Each of the eight numbers surrounding the central 5 has a directional significance (e.g., 1 = North, 9 = South), paralleling the eight cardinal directions used in Tai-Chi stepping patterns (e.g., "Eight Gates and Five Steps").
- **Yin-Yang Duality**: The numbers in the Lo Shu can be grouped into odd and even, representing yang and yin respectively. Tai-Chi choreography also emphasizes alternating yin and yang energies through shifting weight, opening and closing movements.

Moreover, the number 15—the constant sum in the Lo Shu—can be interpreted symbolically as the integration of the self with cosmic order. In Tai-Chi, achieving harmony with the Dao is the ultimate aim.

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Thus, the meditative stillness found at the center of movement corresponds with the central position of **5** in the Lo Shu, both representing a state of perfect balance (Figure 10).

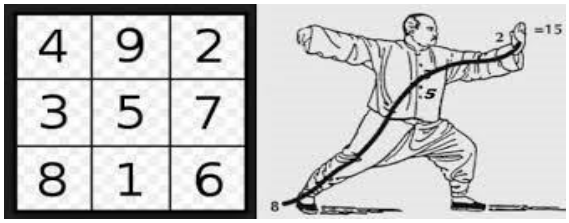

Figure 10. Lo Shu Magic Square and Tai-Chi Movements

Lo Shu square or matrix $\mathbf{H_{3x3}}$ has eight standard variations—these are all the distinct rotations and reflections of the original configuration that still preserve the magic properties. The eight variations are generated by rotating and reflecting the square. They are:

1. Original (0° rotation):

4 9 2
3 5 7
8 1 6

2. Rotate 90° clockwise:

8 3 4
1 5 9
6 7 2 3.

3. Rotate 180°:

6 1 8
7 5 3
2 9 4 4.

4. Rotate 270° clockwise:

2 7 6
9 5 1
4 3 8

5. Reflect horizontally (mirror across vertical axis):

2 9 4
7 5 3
6 1 8

6. Reflect vertically (mirror across horizontal axis):

8 1 6
3 5 7
4 9 2

7. Reflect along main diagonal (top-left to bottom-right):

4 3 8
9 5 1
2 7 6

8. Reflect along secondary diagonal (top-right to bottom-left):

6 7 2
1 5 9
8 3 4

Why Only 8? Mathematically, these 8 configurations represent the symmetry group of a square, known as the dihedral group D_4, which includes:

- 4 rotations (0°, 90°, 180°, 270°)
- 4 reflections (horizontal, vertical, and two diagonal axes)

More depth study of Lo Shu square in modern linear algebra can be found in [So, A. T. P. , Lee, E., Li, K. L., &Leung, D. K. S, 2015]. Each of these transformations applied to the base Lo Shu Square results in a distinct arrangement that still satisfies the magic constant (15 in all rows, columns, and diagonals).

In linear algebra, matrices often represent linear transformations of space such as rotations, scaling, and shears.

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- The trace of matrix H_{3x3}, $Tr(H_{3x3})$ =2+5+8=15. It gives a measure of how a transformation stretches or contracts space along its principal axes. The trace tells the total amount of scaling happening across these directions.
- The determinant of H_{3x3}, $det(H_{3x3})$= -360 (=-8x45, 45^o degree rotation in 2D space). It measures the total volume scaling of space under the matrix transformation.
- The inverse of H_{3x3}, denoted by $H^{-1}{}_{3x3}$ (e. g. $H_{3x3}H^{-1}{}_{3x3}=I_{3x3}$, identity matrix) is given by

-37/360	17/90	-7/360
19/180	1/45	-11/180
23/360	-13/90	53/360

Or

-37	68	-7
38	**8**	-22
23	-52	53

With common factor 1/360. The number at the center of this square is 8 (this agrees with **8** directions in Tai-Chi motions). This square is also a magic square with a common sum of 24 (horizontal, vertical, diagonal sums), and total sum of all numbers is 72.

In observing the magic square and its inverse, we note that the digit sum of $Tr(H_{3x3})$ =15 is **1+5=6**, the same as the digit sum of $Tr(H^{-1}{}_{3x3})$=24 is **2+4=6**. The digit sum of the total sum of H_{3x3} =45 is **4+5=9**, the same as the digit sum of total sum of inverse matrix $H^{-1}{}_{3x3}$=72 is **7+2=9**. Both numbers 6 (Yin as in I-Ching) and 9 (Yang as in IChing) play important roles in I-Ching and Tai-Chi motions.

The trace of $H^{-1}{}_{3x3}$, $Tr(H^{-1}{}_{3x3})$ = 1/15. The determinant of $H^{-1}{}_{3x3}$, $det(H^{-1}{}_{3x3})$=-1/360. This demonstrates the inverse transformation of matrix H_{3x3}. This shows movements of expansions and contractions are symmetrically embedded in Tai-Chi motions.

Application and embodiment Tai-Chi can incorporate the Lo Shu Square in visualizations and footwork, using its grid as a metaphor for spatial awareness. Practitioners may move in patterns that mimic the square's structure to train directional balance and energy alignment with matrix trace and determinant properties of H_{3x3} and $H^{-1}{}_{3x3}$ as discussed above. This application reinforces the square not just as a conceptual model, but as a tool for physical cultivation.

Tai-Chi's fundamental movements can be naturally connected to Lo Shu square. Here we make connections between 8 fundamental Tai-Chi (Taijiquan) movements as described in previous section with Lo Shu square.

1. Ward Off (Peng, 掤): Denoted by **M_1**
2. Roll Back (Lu, 捋): Denoted by **M_9**
3. Press (Ji, 擠): Denoted by **M_3**
4. Push (An, 按): Denoted by **M_7**
5. Pull Down or Pluck (Cai, 採): Denoted by **M_2**
6. Split (Lie, 挒): Denoted by **M_8**
7. Elbow Strike (Zhou, 肘): Denoted by **M_4**
8. Shoulder Strike (Kao, 靠): Denoted by **M_6**

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These 8 movements—**Peng (M_1), Lu(M_9), Ji(M_3), An(M_7), Cai(M_2), Lie(M_8), Zhou(M_4), Kao(M_6)**—are referred to collectively as the "**Eight Gates**" (八门, *Ba Men*), and they form the energetic and tactical basis for Tai-Chi Chuan's martial system. They are frequently practiced in coordination with the "Five Steps" (**五步**, *Wu Bu*): Denoted by X_5, forward, backward, left, right, and center stability—forming the classical "Eight Gates and Five Steps" (Ba Men Wu Bu, **八门五步**) framework.

These Eight Gates and Five Steps of fundamental hand and foot movements can be represented by the following 3x3 matrix:

$\mathbf{H_{3x3}}=$

M_2	M_9	M_4
M_3	X_5	M_7
M_6	M_1	M_8

This 3x3 matrix $\mathbf{H_{3x3}}$ connects Tai-Chi Eight Gates and Five Steps with Lo Shu Square associated with each number.

The central element symbol $\mathbf{X_5}$ captures 5 Tai-Chi foot movements of forward, backward, left, right, and center (standing still). This center position corresponds to Tai-Chi core position of Dantian (丹田). Here the Chinese character 丹(dan), literally means red pellet (small rounded compressed mass of substance), the character 田 (tian), has geometric square shape 田with a cross embedded inside the square, it means the field. Dantian (丹田) is an energy hub of Tai-Chi movements.

Here, the **Dantian (丹田)** refers to an important energy center in the body. It plays a crucial role in cultivating and storing **Qi (氣)**—the vital life energy.

There are actually three main Dantians in Chinese internal practices:

Lower Dantian (下丹田) – Most relevant in Tai-Chi

- **Location**: About 2–3 inches below the navel, centered inside the abdomen.
- **Function**: This is considered the body's main energy storage center and is the foundation of physical vitality and internal power.
- **In Tai-Chi**: Practitioners focus on the Lower Dantian to develop balance, grounding, and internal strength. Movements are often said to originate from or be coordinated with the Dantian.

Middle Dantian (中丹田)

- **Location**: In the center of the chest (heart area).
- **Function**: Associated with emotional energy and breath, connected to the heart and lungs.

1. **Upper Dantian (上丹田)**

- **Location**: In the forehead, between the eyebrows (similar to the "third eye").
- **Function**: Linked to spirit, consciousness, and intuition.

Dantian can be metaphorically compared to concepts like:

- Center of mass (physics)
- Origin point (geometry)
- Control center or energy hub (systems theory)

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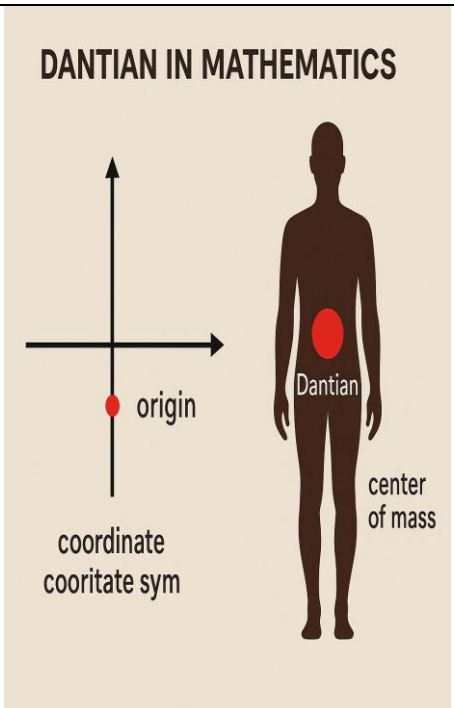

Figure 11. Dantian in Tai-Chi and Mathematics

These comparisons can help explain the functional role of the Dantian in Tai-Chi from a modern or Western perspective (Figure 11).

Other 8 matrix elements capture Tai-Chi hand movements in 4 pairs as (M_1, M_9), (M_3, M_7), (M_2, M_8), and (M_4, M_6). The first 2 pairs of odd number-indexed Tai-Chi movements (M_1, M_9), (M_3, M_7) connect to square faces. The other 2 pairs of even number-indexed Tai-Chi movements (M_2, M_8), and (M_4, M_6) connect to square corners. The sum of subscript index of each pair movement is the common number10 for the ultimate aim.

This matrix H_{3x3} can be seen as a mandala-symbolic map of the universe. In Tai-Chi, the body becomes the mandala in motion, expressing these same principles through spirals, weight shifts, and breath control.

In traditional Chinese martial arts, especially in internal styles like Tai-Chi, the concept of three segments(三节) refers to:

Three Sections/Segaments of the Body:

This is a common structural breakdown:

- **Upper Section (上节)**: Head, shoulders, arms, and hands
- **Middle Section (中节)**: Torso (chest, abdomen, waist)
- **Lower Section (下节)**: Hips, legs, and feet

The idea is that the body moves as a unified whole, and power flows from the ground (feet) → through the waist → to the hands. This is the basis for internal power (内劲).

Three Sections of a Limb:

For example, the **arm** can also be divided into:

- Upper arm (shoulder to elbow)
- Forearm (elbow to wrist)
- Hand (wrist to fingers)

Each "节" (joint/section) must coordinate smoothly to express energy properly. These three-sections flow (3⇄3⇄3) of Tai-Chi movements corresponds to three sequences of matrices $\mathbf{H_{1x1}}$, $\mathbf{H_{3x3}}$, and $\mathbf{H_{9x9}}$:

$$\mathbf{H_{1x1}} = \boxed{\mathbf{X_5}}$$

$$\mathbf{H_{3x3}} = \begin{bmatrix} \mathbf{M_2} & \mathbf{M_9} & \mathbf{M_4} \\ \mathbf{M_3} & \mathbf{X_5} & \mathbf{M_7} \\ \mathbf{M_6} & \mathbf{M_1} & \mathbf{M_8} \end{bmatrix}$$

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$\mathbf{H_{9x9}}$ =

M_2	M_9	M_4	M_8	M_3	M_4	M_6	M_1	M_8
M_3	X5	M_7	M_1	X5	M_9	M_3	X5	M_7
M_6	M_1	M_8	M_6	M_7	M_2	M_2	M_9	M_4
M_2	M_7	M_6	M_2	M_9	M_4	M_2	M_9	M_4
M_9	X5	M_1	M_3	X5	M_7	M_7	X5	M_3
M_4	M_3	M_8	M_6	M_1	M_8	M_6	M_1	M_8
M_8	M_1	M_6	M_4	M_3	M_8	M_6	M_7	M_2
M_3	X5	M_7	M_9	X5	M_1	M_1	X5	M_9
M_4	M_9	M_2	M_2	M_7	M_6	M_8	M_3	M_4

This 9x9 matrix $\mathbf{H_{9x9}}$ is based on symmetry group of squares by fixing the $\mathbf{H_{3x3}}$ at the central position along with 4 rotation and 4 reflection matrices from H_{3x3}. In each block of 3x3 matrix, $\mathbf{X_5}$ is at the center. This matrix $\mathbf{H_{9x9}}$ captures the flow of Tai-Chi motion originating from Dantian $\mathbf{X_5}$ to all body sections by matrix transformations:

$$\mathbf{X_5 <-> H_{3x3} <-> H_{9x9}}$$

Another 9x9 magic square of 81 numbers {1, 2, 3, 4, 5, 6,…, 81} can be generated (as illustrated at The Lo Shu Magic Square (雒書 Luò Shū) - YouTube) as shown below:

31	76	13	36	81	18	29	74	11
22	40	58	27	45	63	20	38	56
67	4	49	72	9	54	65	2	47
30	75	12	32	77	13	34	79	16
21	39	57	23	41	59	25	43	61
66	3	48	68	5	50	70	7	52
35	80	17	28	73	10	33	78	15
26	44	62	19	37	55	24	42	60
71	8	53	64	1	46	69	6	51

The magic sum of this 9x9 square is $(1/2)9(9^2+1)$ = **369**. It comprises of 9 3x3 magic squares as highlighted with different shades. Each 3x3 magic square is anchored with the numbers from the original 3x3 Lo Shu square. The 9 magic sums of 9 magic square also form as 3x3 magic square.

120	135	114
117	123	129
132	111	126

This 9x9 matrix offers a principal guide of Tai-Chi motion originating from Dantian at central number **5**, expanding the motions symmetrically through 3 sections of human body to reach maximum balance of 9x9 magic sum of **369.**

In conclusion, the Lo Shu Magic Square and Tai-Chi movements represent two modes of expressing a shared cosmological philosophy. One is mathematical and symbolic; the other is kinetic and embodied. Yet both encapsulate a vision of harmony, transformation, and balance deeply rooted in Chinese metaphysical thought. By understanding their interconnections, we gain insight into the holistic nature of classical Chinese culture, where numbers, nature, and the body are not separate domains but interwoven threads in the tapestry of the Dao.

Lo Shu Square-Guided Tai-Chi Teaching and Learning (Figure 3.6)

Below is a Lo Shu Square-guided Tai-Chi practice that integrates the Lo Shu magic square's structure and symbolic meaning into a meditative flow of 9 movements, each associated with direction, number, and energetic focus. Please note this guide is used for reference only and can be modified and applied to various Tai-Chi

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movements for maximum of balance and harmony.

Lo Shu Square Structure:

4	9	2
3	5	7
8	1	6

Format:

- Each number corresponds to a direction and a symbolic Tai-Chi movement.
- You begin at the center (5), then move following the square's numerological order (1 through 9).
- Use each movement as a focal point for intention and energy alignment.

Opening:

Center Yourself (5 – Center)

- Movement: *Embrace the Ball* (Wu Ji (无) posture)
- Element: Earth
- Focus: Stability, harmony, grounding
- Breath: Inhale to gather energy, exhale to settle it in the Dantian.

Numbered Sequence:

1. (1 – South)
    - Movement: *Opening the Gate* (slow palm press forward)
    - Element: Water
    - Focus: Clarity, flow, letting go
    - Direction: Step gently to the south
    - *"With clarity, I step into the flow."*
2. (2 – Southeast)
    - Movement: *Crane Spreads Wings*
    - Element: Earth
    - Focus: Balance, expansion
    - Direction: Shift diagonally
    - *"I expand with grace and balance."*
3. (3 – East)
    - Movement: *Brush Knee and Push*
    - Element: Wood
    - Focus: Growth, confidence
    - Direction: Step to the east
    - *"I grow steadily and move forward."*
4. (4 – Northeast)
    - Movement: *Parting the Wild Horse's Mane*
    - Element: Wood
    - Focus: Creativity, assertiveness
    - Direction: Step diagonally
    - *"With strength, I part the currents of life."*

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5. (5 – Return to Center)
    - Movement: *Holding the Moon*
    - Focus: Integration
    - *"I return to my center, balanced and whole."*
6. (6 – Northwest)
    - Movement: *White Crane Cools Wings*
    - Element: Metal
    - Focus: Reflection, Stillness
    - Direction: Diagonal shift
    - *"With stillness, I embrace clarity."*
7. (7 – West)
    - Movement: *Wave Hands Like Clouds*
    - Element: Metal
    - Focus: Transition, breath
    - Direction: Step to the west
    - *"I drift with the rhythm of change."*
8. (8 – Southwest)
    - Movement: *Repulse the Monkey*
    - Element: Earth
    - Focus: Releasing the past -
    - Direction: Step diagonally
    - *"I gently release what no longer serves."*
9. (9 – North)
    - Movement: *Golden Rooster Stands on One Leg*
    - Element: Fire
    - Focus: Focus, resilience
    - Direction: Step to the north
    - *"I stand tall in fiery balance."*

Closing:

Return to the Center (5)

- Movement: *Closing Form* (hands lower, feet together)
- Breath: Deep and slow, smile inward
- *"Balanced in all directions, I return to stillness."*

A diagram (Figure 12) of Lo Shu Square Guided Tai-Chi Practice is illustrated below for easy access.

Figure 12. A Diagram of Lo Shu Square Guided Tai-Chi Practice

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Sequencing Tai-Chi Movements with Fibonacci Numbers

Fibonacci Numbers and Tai-Chi Motions

Mathematics has long been regarded as the universal language through which natural phenomena can be described and understood. Among its many constructs, the Fibonacci sequence (or numbers)—0, 1, 1, 2, 3, 5, 8, 13, 21, etc.—has garnered significant attention for its recurrence in natural growth patterns and its association with the golden ratio (approximately 1.618). Separately, Tai-Chi emphasizes slow, flowing, spiral-based movements designed to harmonize the body's energy and promote balance and health. While seemingly disparate, these two fields share a surprising number of structural and conceptual parallels that warrant rigorous academic exploration (Zeiger, 2008, He, 2025).

The Fibonacci sequence is defined recursively as in Figure 13 below:

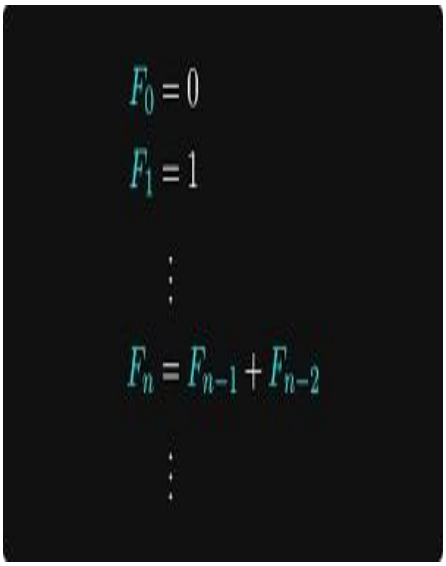

Figure 13. Fibonacci Sequence Recurrence Relation

This mathematical growth model appears in biological systems such as phyllotaxis (leaf arrangements), shell spirals, and branching in trees (Livio, 2002). A geometrical representation of Fibonacci numbers often leads to a logarithmic spiral that approximates the golden spiral, a curve frequently observed in natural phenomena. The spiral form provides a bridge between abstract mathematical concepts and physical structures.

The Fibonacci sequence (0, 1, 1, 2, 3, 5, 8, ...) naturally occurs in flora, fauna, and phyllotaxis. It represents organic growth and proportional scaling as illustrated in Figure 14.

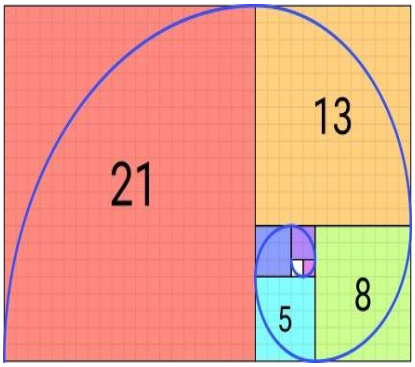

Figure 14 Fibonacci Sequence and Fibonacci Spiral

Tao, believed as source and grounds of all beings and creatures, literally means "the way" of cycle from "nothing (Wuji 无极)" to everything (Taiji 太极) and return to nothing (Wuji 无极). Laozi (sixth century BCE), his book *Tao-Te Ching* (400 BC), a work roughly five thousand characters long, attributed to the core of Taoism:

"Tao produced the One, One
produced the Two, Two
produced the Three, and
Three produced ten thousand things".

Here, the One, Two, and Three do not indicate anything specific, just a general cosmological formula: from Nothing to Being, one to multitude, and simple to complex. This formula of Tao being the primordial root of all beings and creatures,

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is connected to well-known Fibonacci numbers.

Tao's Mathematics Formula:

Let 0 be the origin or Tao. Then the 0 produces a pair of an invisible 1 and a visible 1. Combining both 1's produce 2. Adding each 1 with 2 produces 3, 2+3 =5, 3+5=8, 5+8=13.

This sequence of Tao's numbers embraces basic numbers of Tai-Chi motions: 0wuji; 1-unity; 2-Yin-Yang duality; 3-inner 3-in-1; 5-5 directional foot movements; 88 hand movements and Fibonacci numbers. Considering the first three pairs of numbers (0, 1), (1, 2), and (2,3) from Fibonacci sequence, it leads us the following:

Three basic rules/principles of Tai-Chi motions

1. ***(0, 1)-based Yin Yang Exchange Principle:*** Tai-Chi motion follows a process of Yin Yang energy exchange. During Tai-Chi motion Yin's position becomes Yang's position and Yang's position becomes Yin's position. The spectrum of Tai-Chi positions is between 0 and 1.

2. ***(1, 2)-based Middle Point Balance Principle:*** During the exchange between Yin's position and Yang's position, it goes through the middle point 1/2 of the Tai-Chi interval [0, 1] to balance the Yin Yang exchange. The middle point 1/2 divides unity and unites 2 opposites.

3. ***(2, 3)-based Parts-Whole Coordination Principle:*** The Tai-Chi motion is primarily governed by a core rectangle base with 4 corner points and 1 central point. The central point (Dantian) guides 4 directional points of rectangle. These 5 points that connect as a backbone move in a whole coordination. A special ratio of 2:3 is intertwined in Tai-Chi spiral movements within this core base (Figure 15).

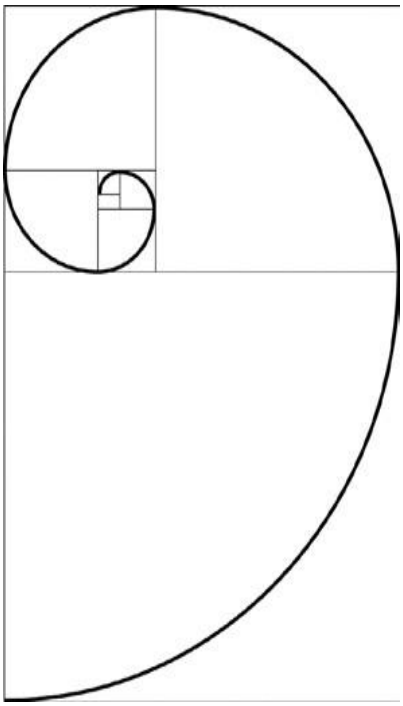

Figure 15. Fibonacci Golden Rectangle as a Core of Tai-Chi Motion

In Tai-Chi, Fibonacci numbers can structure breath patterns, repetition cycles, and time intervals. For example, a breath cycle might be performed as 3-count inhale, 5count exhale, creating a rhythm that mirrors nature's balance (Table 8).

Table 8. Fibonacci-Based Tai-Chi Breathing Intervals

Movement	**Inhale (counts)**	**Exhale (counts)**

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Push Hands	2	3
Ward Off	3	5
Brush Knee	5	8

This sequencing nurtures rhythmic harmony and emotional regulation during practice.

It is well known that Tai-Chi motions are characterized by circularity and spiraling dynamics. Techniques such as "Silk Reeling" (纏絲功 *chán sī gōng*) emphasize spiraling force generation throughout the body, resembling the logarithmic spirals derived from Fibonacci-related geometry (Cohen, 1997, Ghyka, 1946). Movements are executed in arcs and circular trajectories rather than linear paths, creating a kinetic flow that parallels the expansion and continuity seen in Fibonacci-based spirals.

Furthermore, the practice of Tai-Chi emphasizes coordinated movement between limbs and the torso, like the self-similarity and recursive structure of the Fibonacci sequence. Just as each Fibonacci number is formed by summing its predecessors, Tai-Chi forms evolve through the repetition, variation, and integration of previous movements, suggesting a recursive aesthetic and structural principle in its choreography and movement.

Tai-Chi forms are practiced in sequential series of postures, each flowing into the next with unbroken continuity. This structured unfolding bears resemblance to the additive nature of the Fibonacci sequence. For example, a typical Yang-style 24-form might begin with a simple opening movement and gradually increase in complexity, repeating and expanding upon earlier movements. The developmental logic of these sequences mimics the Fibonacci growth model: from simplicity to complexity through orderly progression.

From a choreographic standpoint, this progressive buildup is not unlike algorithmic pattern generation in mathematics. Studies in movement analysis (Laban, 1971) suggest that such ordered repetition and variation can create aesthetic cohesion, much as the Fibonacci sequence introduces beauty and proportion in visual art and architecture.

Beyond structural similarities, Tai-Chi and the Fibonacci sequence share philosophical affinities in their reflection of natural order and harmony. Rooted in Taoist thought, Tai-Chi represents the interaction of Yin and Yang, the dual yet complementary forces that animate all things (Kirkland, 2004). The Fibonacci sequence, although mathematical in nature, captures this same sense of organic growth and balance.

The golden ratio (will be further described in next chapter) derived from the Fibonacci sequence is often associated with aesthetic perfection and the inherent order of the universe. In a similar manner, Tai-Chi strives for internal and external harmony through the cultivation of energy flow, balance, and rhythm. Thus, both the Fibonacci sequence and Tai-Chi can be seen as different modalities for expressing the same universal principles of dynamic balance and structured emergence.

Recognizing Fibonacci patterns in Tai-Chi offers valuable implications for interdisciplinary research. It opens a pathway for using mathematical modeling to analyze movement arts and vice versa. Potential applications include biomechanical studies, somatic education,

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and even artificial intelligence, where Fibonacci algorithms could inform the programming of lifelike motion in humanoid robotics (Liu et al., 2015). Additionally, this connection enriches the pedagogy of both subjects, allowing students to explore abstract mathematical ideas through embodied Tai-Chi practice.

While originating from different cultural, historical, and intellectual lineages, the Fibonacci sequence and Tai-Chi motions converge through their shared structural, dynamic, and philosophical properties. The spiraling forms, recursive patterns, and aesthetic coherence evident in Tai-Chi mirror the mathematical elegance of the Fibonacci series. Such interdisciplinary comparisons not only deepen our understanding of each field but also affirm the broader unity between mathematical abstraction and physical embodiment. Ultimately, this exploration underscores the possibility that all forms of knowledge—scientific, artistic, and philosophical—are interconnected through the universal patterns that govern both mind and matter.

Fibonacci Numbers Guided Tai-Chi Teaching and Learning (Figure 4.4)

As a Tai-Chi practice reference, we introduce Fibonacci Numbers Guided Tai-Chi Practice inspired by the first 8 Fibonacci numbers. The structure incorporates repetition, breath, and movement length based on the sequence—ideal for a meditative, spiral-like flow.

Sequence Structure: 0, 1, 1, 2, 3, 5, 8, 13, 21

Theme: Spiraling energy, organic growth, harmonic breath

Opening (Stillness & Intention)

Preparation – Wu Ji （无极）Posture

- Feet shoulder-width apart, knees soft
- Arms relaxed, spine tall, eyes gently open or closed
- **Breath:** Deep inhale, slower exhale
- **Focus:** “I begin in stillness, open to growth.”

The Fibonacci Flow

Gather the Qi (Count 1 – One Breath)

- **Movement:** Raise hands slowly to chest height, palms facing inward
- **Focus:** Centering
- *“I gather energy into my center.”*

Sink the Qi (Count 1 – One Breath)

- **Movement:** Gently lower hands to lower Dantian （丹田）
- **Focus:** Grounding
- *“I root myself in the earth.”*

Opening Wings (Count 2 – Two Movements)

- **Movement 1:** Step left, arms open wide (inhale)
- **Movement 2:** Return arms to center (exhale)
- **Focus:** Expansion and return
- *“I open to the world and return to self.”*

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Spiral Hands (Wave Hands Like Clouds-Yunshou(云手)) (Count 3 – Three Cloud Waves)

- Flow to the left (1), center (2), right (3)
- Gentle waist rotation leads the movement
- **Focus:** Flow and change
- *"I drift through the rhythm of life."*

Five Element Flow

- **Movement:** A short sequence representing each element:
    1. Earth – *Embrace the Ball*
    2. Metal – *White Crane Cools Wings*
    3. Water – *Push the Wave*
    4. Wood – *Brush Knee*
    5. Fire – *Part the Wild Horse's Mane*
- **Focus:** Balance and cyclical harmony
- *"All elements arise and return within me."*

Lotus Spiral (Circular Movement)

- Perform 8 flowing spiral movements with the arms and waist
- Begin small, gradually expanding each circle like a blooming lotus
- Step lightly side to side as you spiral
- **Focus:** Growth, fluid expansion
- *"I spiral outward in graceful harmony."*

Pulse of Qi (Walking Meditation with Breath)

- 13 steps in slow walking Tai-Chi, arms floating gently with each breath
- Alternate stepping left and right
- Keep your breath and pace even and calm
- **Focus:** Mindful movement, present awareness
- *"With each step, I honor the present moment."*

Flowing Sequence

- Freestyle flow combining earlier movements (gather, open, spiral, wave, walk)
- Allow breath to guide you through 21 continuous seconds or movements
- Can be done eyes closed or open
- **Focus:** Integration, surrender
- *"I flow with life's sacred spiral."*

Closing (Return to Stillness)

Hands return to Dantian, feet together, eyes soft

- **Breath:** Deep inhale through nose, long exhale through mouth
- *"I return to the source, full and complete."*

A diagram of Fibonacci Numbers-Guided Tai-Chi Practice (Figure 16) is illustrated

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below for easy access and practice reference.

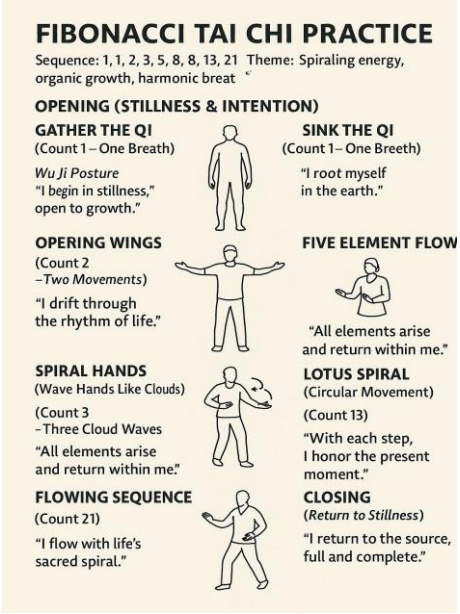

Figure 16. A Diagram of Fibonacci Numbers-Guided Tai-Chi Practice

Breathing Tai-Chi As Golden Ratio Φ≈1.618

Golden Ratio and Tai-Chi Motions

In the previous section, we connected Tai-Chi motions with Fibonacci numbers and touched the concept of Golden ratio generated by Fibonacci numbers. This section we further explore the conceptual and structural relationship between the Golden Ratio (**φ ≈ 1.6180339887**) and Tai-Chi motions. By examining principles from geometry, biomechanics, and Taoist philosophy, the analysis reveals how the Golden Ratio serves as both a mathematical and aesthetic principle that manifests in Tai- Chi's forms, body mechanics, and movement transitions. The study suggests that the harmonization found in Tai-Chi may reflect the same proportional aesthetics and natural efficiency that the Golden Ratio symbolizes across disciplines.

The Golden Ratio has captivated philosophers, artists, and scientists for centuries due to its pervasive presence in natural structures, classical architecture, and artistic compositions. Simultaneously, Tai-Chi, as a martial art grounded in Taoist philosophy and traditional Chinese medicine, emphasizes balance, flow, and natural movement. While these domains may appear distinct, a deeper investigation reveals that both the Golden Ratio and Tai-Chi are underpinned by principles of natural harmony, balance, and efficient energy distribution. We describe how the Golden Ratio informs the aesthetics and biomechanics of Tai-Chi practice and how these insights deepen the understanding of embodied mathematics.

The Golden Ratio, represented by the Greek letter φ (phi), is a mathematical constant derived from the division of a line into two parts such that the ratio of the whole to the longer part is the same as the ratio of the longer part to the shorter (Figure 17).

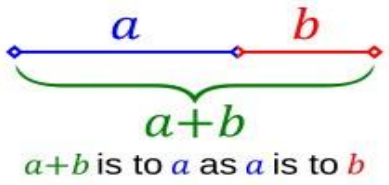

Figure 17 Geometry of Golden Ratio

Algebraically, this is expressed as:
(a+b)/a=a/b=φ≈1.618

This ratio has been found in biological systems (such as phyllotaxis in plants and human anatomy), architecture (notably in the Parthenon), and visual art (e.g., works of Leonardo da Vinci). It is often associated with aesthetic beauty and optimal structural balance.

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Tai-Chi is an internal martial art characterized by slow, continuous and harmonious movements that aim to cultivate Qi (life energy), improve health, and develop martial skill. Rooted in Taoist cosmology, Tai-Chi embodies the interplay of Yin and Yang—the complementary forces of nature. Movements in Tai-Chi reflect the Taoist ideals of naturalness, fluidity, and dynamic equilibrium.

A typical Tai-Chi form is composed of a series of postures connected through smooth transitions. Each motion is governed by principles such as rootedness, relaxation (松 song), and spiraling energy (纏絲功, chán sī gōng). These principles align not only with philosophical ideals but also with biomechanical efficiency and spatial harmony.

Human body proportions approximate the Golden Ratio in various dimensions (Figure 18). For instance, the ratio between the forearm and the hand, the distance from the navel to the floor and the full height of the body, or the relative position of the limbs during movement often reflect this proportion. Leonardo da Vinci's *Vitruvian Man* famously illustrates the Golden Ratio in human anatomy, underscoring the body's potential for naturally harmonious proportion (Hemenway, 2005).

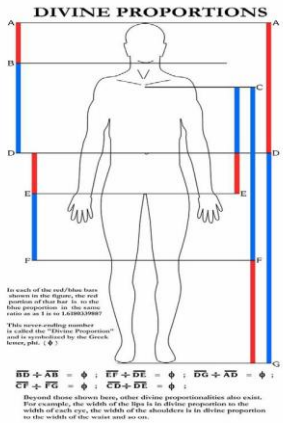

Figure 18 Goden Ratio in Human Body

In Tai-Chi, movement sequences often emphasize rounded shapes, arcs, and spirals—geometric features wherein the Golden Ratio frequently appears. These motions are designed to maximize biomechanical efficiency and energy flow, minimizing muscular tension and leveraging natural bodily alignment.

Tai-Chi forms are not arbitrary sequences but choreographed with a keen sense of timing, spatial awareness, and energetic flow. Scholars and practitioners have noted that transitions in movement often adhere to ratios that echo φ, though not always consciously. For instance, the transition from one stance to another may involve shifting weight in a proportioned manner that approximates the Golden Ratio, enabling smoother, more efficient movement.

Moreover, many postures in Tai-Chi demonstrate body alignments that align with φbased geometric structures. A practitioner moving from "Grasp the Bird's Tail" to "Single Whip," for instance, might be observed to create visual arcs and segmentations within the body that resemble golden rectangles or logarithmic spirals. This alignment enhances both the aesthetic presentation and the functional power delivery.

Perhaps the most compelling connection between the Golden Ratio and Tai-Chi lies in the use of spiraling motion. The logarithmic spiral, often found in shells and galaxies, grows in a pattern governed by φ. Tai-Chi's energy path—chán sī gōng —mimics this spiral, especially in silk-reeling exercises (纏絲功, chán sī gōng) derived from Chen-style Tai Chi.

These spirals are not merely artistic flourishes but are biomechanically advantageous. They enable continuous motion, maximize force transmission through the kinetic chain, and facilitate rooted balance. The similarity between

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these spirals and those dictated by the Golden Ratio suggests a deeper mathematical resonance in Tai-Chi's traditional motion vocabulary.

Both Taoist philosophy and the Golden Ratio seek harmony in opposites and unity in diversity. The Taoist idea of *wu wei* (effortless action) and the Golden Ratio's natural efficiency converge in Tai-Chi practice, wherein form follows function and movements are optimized for energy conservation.

This philosophical congruence supports the idea that the Golden Ratio is not merely a mathematical curiosity (Figure 19) but a universal principle mirrored in human movement, art, and nature. Tai-Chi, as a living embodiment of Taoist principles, thus becomes a kinetic expression of the Golden Ratio.

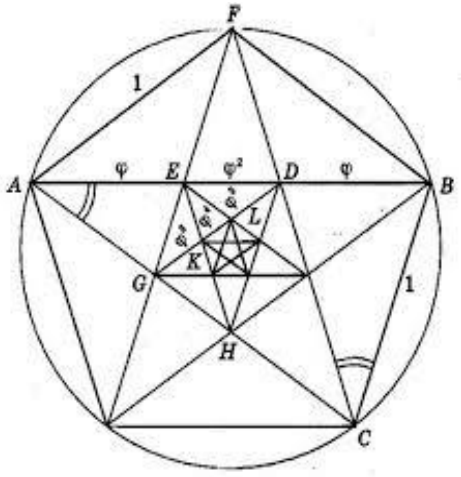

Figure 19 Goden Ratio in Pentagon (5 Node Elements)

The Golden Ratio and Tai-Chi represent distinct yet interrelated systems of harmony—one grounded in mathematical abstraction and the other in embodied movement. Through careful practice of form, proportion, and motion, it becomes evident that Tai-Chi subtly reflects the aesthetic and functional qualities of φ. While the Golden Ratio may not have been explicitly referenced in the historical development of Tai-Chi, its presence in natural forms and human biomechanics suggests that Tai-Chi, in its pursuit of harmony, inevitably converges with this universal proportion.

This intersection invites further interdisciplinary study at the confluence of mathematics, kinesiology, and Eastern philosophy, offering deeper insight into how ancient practices may intuitively align with universal patterns of order and beauty.

A Tai-Chi practice guided by the **Golden Ratio (φ ≈ 1.618)** can create a unique, harmonizing experience that aligns movement, breath, and time with this natural proportion found in art, nature, and architecture. Here's a structured Tai-Chi flow using the Golden Ratio as a principle for timing, movement transitions, and spatial flow (Zeiger and Lo 2012).

Golden Ratio Guided Tai-Chi Teaching and Learning (Figure 5.4)

Structure: The session is divided based on the Golden Ratio into segments that follow approximate φ proportions:

- Warm-Up (11 min)
- Flow Sequence (18 min)
- Closing Stillness (1 min)

Golden Warm-Up (11 minutes)

Grounding & Spiral Breath (3 minutes)

- Stand in Wu Ji posture (feet shoulder-width, knees slightly bent, arms relaxed).
- Inhale slowly for 4 counts, exhale for 6.5 counts (φ breath).
- Imagine breath spiraling from soles to crown and back.

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Neck, Shoulder & Spine Flow (5 minutes)

- Slow circular shoulder rolls (inhale up for 2.5 counts, exhale down for 4).
- Golden Neck Turn: turn head left slowly (inhale 2), center (pause), turn right (exhale 3.2).
- Wave spine forward and back using φ-timed flow.

Silk Reeling – φ Rhythm (3 minutes)

- Use silk-reeling motion (Dan Tian spiraling).
- Circle arms slowly out (1 count), in (1.618 count), shifting weight with golden timing.

Golden Ratio Tai-Chi Flow (18 minutes)

Choose 3–5 simplified forms inspired by Yang Style Tai-Chi and perform each in a φtempo cycle.

Move 1: Parting the Wild Horse's Mane

- Left → Right → Left
- Inhale to step (shorter count), exhale to sink (longer count).

Move 2: White Crane Spreads Wings

- Arms float up (1), descend gently (1.618)
- Spine upright, breath synchronized

Move 3: Brush Knee and Push

- Emphasize φ in foot placement: back stance 1-unit, front stance 1.618 units
- Push hands out on exhale (long), retract on inhale (short)

Move 4: Cloud Hands

- Use spiraling φ patterns — hands trace inward spirals (1 count), outward spirals (1.618)
- Weight shifts subtly follow this ratio

Move 5: Golden Rooster Stands on One Leg

- Balance time: left leg (1), right leg (1.618) — or vice versa
- Breath supports stability

Closing Stillness (1 minute)

Standing Meditation – "Holding the Moon"

- Imagine a glowing orb (φ-proportioned) between your hands.
- Breathe once more: Inhale 4, exhale 6.5
- Feel the harmony, spiral awareness inward.

Tips for Practicing with the Golden Ratio

- Use a metronome or breath tracker that allows for φ-based timing (e.g., 5s inhale / 8s exhale).
- Visualize movements tracing golden spirals or arcs.
- Align transitions naturally — let the *longer side* of the breath or movement lead.
- Repetition: practice each movement for a φ-based cycle (e.g., 5, then 8 reps).

Please also note that these are based on a 30-minute session where:

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- Total time / φ ≈ 18.5 minutes (main flow)
- Remaining ≈ 11.5 minutes (prep and close, also split via φ)

We'll also use breath counts and movement lengths that mirror Golden Ratio relationships:

- Step ratios: 1: 1.618
- Breaths: inhale (1), exhale (1.618), etc.

A diagram of Golden Ratio Guided Tai Chi Practice is illustrated below (Figure 20) for easy access and reference only.

Figure 20. A Diagram of Golden Ratio Guided Tai Chi Practice

Balancing Tai-Chi Movements as Lambdoma Harmonics

Lambdoma Harmonics and Tai-Chi Motions

In previous sections, we demonstrated the connections and parallels between Tai-Chi motions and Lo Shu magic square, Fibonacci numbers, and Golden ratios. These connections echo the same paradigm shifts as presented in the work *"The Tao of Physics: An Exploration of the Parallels between Modern Physics and Eastern Mysticism"* [Capra, F. 2000]. Along with this same pathway, we investigate the intersection between Tai-Chi motions and Lambdoma harmonics--an ancient matrix of musical and mathematical proportions. Drawing from Pythagorean harmonic theory, Chinese energetic frameworks, and modern movement science, this parallel posits that Tai-Chi embodies harmonic principles analogous to those in the Lambdoma Matrix (Lamb, 1980). Through structural, energetic, and philosophical lenses, it shows that both systems reflect a universal order grounded in frequency, proportion, and resonance, and that Tai-Chi movements can be interpreted as physical manifestations of harmonic coherence.

The concept of harmony transcends disciplines, appearing in mathematics, music, cosmology, and movement. The Lambdoma Matrix—attributed to the Pythagorean tradition—is a numerical model that represents harmonic ratios and their relationships. Though emerging from distinct cultural and historical backgrounds, both Lambdoma harmonics and Tai-Chi motions encode universal principles of balance, resonance, and proportion. This section explores these connections, suggesting that Tai-Chi's physical motions and energy dynamics can be understood as kinetic expressions of harmonic structure akin to the Lambdoma framework.

The Lambdoma Matrix is a visual and mathematical representation of harmonic ratios arranged in a grid where each point corresponds to the relationship between two frequencies. The matrix is constructed using simple whole-number ratios, such as 1:2 (octave), 2:3 (perfect fifth), and 3:4

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(perfect fourth), which form the basis of musical consonance in Pythagorean tuning.

These ratios are not just auditory phenomena but also geometric and vibrational relationships found throughout nature—in the proportions of planetary orbits, the spacing of atoms, and even in the human body. In essence, the Lambdoma represents a universal harmonic order, wherein all parts relate to the whole through proportion and frequency.

Tai-Chi motion is more than a martial art; it is a movement meditation that integrates breath, mind, and body in a continuous flow of motion. Central to Tai-Chi is the concept of *qi*, the vital energy that flows through the body's meridians, and the practice is designed to cultivate, balance, and circulate this energy.

Each Tai-Chi form or movement can be broken down into wave-like patterns, circular trajectories, and spiral motions, reflecting principles of periodicity and resonance. Movements are slow, deliberate, and rhythmic qualities shared with harmonic oscillations. The interplay of stillness and motion, of Yin and Yang, mirrors the wave interference and equilibrium seen in harmonic systems.

The correspondence between Lambdoma harmonics and Tai-Chi motion can be explored in three primary domains: proportional movement, energetic vibration, and philosophical coherence.

Tai-Chi motion emphasizes proportionality in stance, timing, and spatial extension. The body's segments work in coordination, producing movement patterns that can be described using harmonic ratios. For example, a movement such as "Wave Hands Like Clouds" follows a sinusoidal path that visually resembles the curves of wave functions. Geometric shapes of Cloud Hands Movements have the following characteristics:

Circles and Arcs:

The hands and arms trace circular or arc-like paths in both clockwise and counterclockwise directions. Each hand moves in a continuous, smooth circular pattern, typically at chest or shoulder level. ○ The circles are not perfectly planar but follow a three-dimensional, spherical trajectory. This is because the arms move in a relaxed, slightly curved manner, adapting to the natural curvature of the body and the shifting of weight. ○ The hands often move in opposing directions: while one hand traces a clockwise circle, the other may trace a counterclockwise circle, creating a dynamic, interwoven pattern.

Elliptical Patterns:

Depending on the Tai Chi style (e.g., Yang, Chen, or Wu), the circular paths may sometimes elongate slightly, forming elliptical shapes rather than perfect circles. This elongation occurs due to the extension and retraction of the arms as the body shifts weight from one leg to the other.

Spiral and Helical Motions:

When viewed in the context of the whole body, the hand movements can be seen as part of a spiral or helical pattern. This is because the arms move in coordination with the torso, which rotates gently, and the waist, which spirals to guide the motion. ○ The spiraling effect is enhanced by the shifting of weight and the slight turning of the body, creating a sense of continuous flow that resembles a three-dimensional helix.

Symmetrical and Mirrored Paths:

The movements of the two hands are often symmetrical or mirrored, with one hand rising as the other falls, or one moving

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outward as the other moves inward. This creates a balanced, Yin-Yang-like geometric interplay, where the paths of the hands complement each other. ○ The symmetry is not rigid but fluid, adapting to the natural rhythm of the body's motion.

Wave-Like Flow:

The overall motion of Cloud Hands resembles a wave-like pattern, as the hands flow smoothly without abrupt stops or starts. The geometric shape can be visualized as a series of overlapping, undulating curves that connect the circular motions of each hand.

The transitions between stances may approximate harmonic subdivisions, such as dividing motion into 2:1 or 3:2 tempo ratios, optimizing biomechanical efficiency and aesthetic balance (Figure 21).

Figure 21. Lambdoma Harmonic Ratios:(https://demonstrations.wolfram.com/LambdomaMatrix/)

Traditional Chinese medicine posits that the body vibrates with internal energies that can be tuned or regulated through movement and breath. In this sense, Tai-Chi functions as a practice of vibrational medicine, tuning the human system to a coherent frequency. The Lambdoma Matrix, as a map of resonant intervals, serves as a metaphorical model for this energetic attunement.

Modern research into biofield science and frequency healing has also explored how bodily systems respond to sound and movement-based frequencies. Practicing Tai-Chi can entrain the body's rhythms (heart rate, breath, neural oscillations) in a way that resembles the alignment of tones within the Lambdoma spectrum.

Both Tai-Chi and the Lambdoma reflect a worldview in which the universe is governed by patterns of order and resonance. The Taoist concept of the Tao, the way or the path, is akin to the harmonic logos in Pythagorean thought—a guiding principle of unity underlying apparent diversity. Just as the Lambdoma organizes musical intervals into a coherent system, Tai-Chi organizes body movements into a choreography of interrelated actions that reflect cosmic order.

The visualization of Lambdoma harmonics often involves geometric forms such as spirals, lattices, and waveforms (Figure 22). These echoed in Tai-Chi through spiral energy (纏絲勁 *chán sī gōng*), circular footwork, and the toroidal shapes traced by limbs in motion. In both domains, geometry serves as the bridge between the abstract and the embodied.

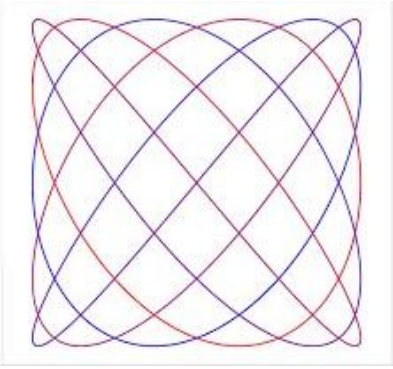

Figure 22. Lambdoma Resonance Harmonics

Notably, Tai-Chi's rotational energy patterns are not unlike the rotational symmetry found in harmonic wave

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interference. These dynamic geometries foster internal alignment and external coherence, reinforcing the notion that Tai-Chi motion is not just an art of movement but of harmonic embodiment.

Understanding Tai-Chi through the lens of Lambdoma harmonics enriches both the philosophical and practical dimensions of training. Teachers can explore rhythm, ratio, and breath alignment using musical metaphors or tools such as metronomes, gongs, or tuning forks to reinforce harmonic timing. Advanced practitioners may develop sensitivity to frequency resonance in the body, integrating sound and movement into a holistic practice of somatic awareness.

Moreover, this interdisciplinary perspective supports modern integrative medicine approaches, wherein sound therapy, movement therapy, and bioenergetic healing converge. Tai-Chi becomes not just a martial art, but a living instrument tuned to the harmony of the cosmos.

The relationship between Lambdoma harmonics and Tai-Chi motions reveals a profound unity between ancient mathematical-musical systems and embodied energetic practices. Both disciplines seek resonance—between parts of a system, between the individual and the cosmos, and between internal intention and external expression. By viewing Tai-Chi as a kinetic manifestation of harmonic principles, and the Lambdoma as a symbolic language of universal order, we can better appreciate the role of movement, sound, and proportion in cultivating harmony within and beyond the self.

Lambdoma Harmonics-Guided Tai-Chi Teaching and Learning (Figure 6.3)

A Lambdoma Harmonics-Guided Tai-Chi Practice offers a deep, meditative journey by aligning body movements with the harmonic matrix of the Lambdoma diagram—a model representing musical intervals and the unity of vibration and ratio. This ancient Pythagorean model is a grid of frequency ratios (e.g., 1:1, 2:1, 3:2, 4:3), and can beautifully guide breath, motion, and mental focus. Lambdoma Harmonics Guided Tai-Chi Teaching and Learning

Principles:

- Movements and breaths are guided by harmonic ratios (e.g., 2:1 for inhale:exhale).
- Postures reflect interval energy (1:1 = unity/stillness, 3:2 = dynamic harmony).
- Direction and sound can enhance effect—tones or vocal overtones may be used optionally.

Harmonic Centering (5 Minutes)

Breath Ratio: 1:1 (Unity)

- Stand in Wu Ji posture
- Inhale for 4 counts, exhale for 4 counts
- Visualize the Lambdoma square (start with the central 1:1 cell), letting it radiate from your Dantian

Mantra: "Tone of Unity"

- Hum softly at a mid-pitch tone (if desired), holding it steady to feel vibration in chest

Primary Movement Sequence (20 Minutes)

Each movement is performed for ~4 minutes and aligned with a harmonic interval from the Lambdoma matrix.

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Interval (Octave Resonance)

Move: *Raising Hands to the Heavens*

- Inhale (slowly) for 4 counts, exhale (double speed) for 2 counts
- Reach upward, then slowly descend arms, grounding energy

Octave = doubling, representing expansion and return

Interval (Perfect Fifth – Balance in Motion)

Move: *Brush Knee and Push*

- Inhale for 3 counts, exhale for 2
- Weight shift and push flow in this rhythm
- Create spiraling intention from Dantian outward

Fifth = motion and harmony, often associated with flow and expression

Interval (Perfect Fourth – Structural Integrity)

Move: *Wave Hands Like Clouds*

- Hand passes (inhale 4, exhale 3)
- Side-to-side shifting with soft spirals, head steady
- Feel connection from Earth to Heaven

Fourth = structure, foundational harmony between parts

Interval (Major Third – Creative Expression)

Move: *Golden Rooster Stands on One Leg*

- Hold balance for 5 counts, release to stance in 4
- Switch sides after one full breath cycle
- Hands in soft mudra in front of chest

Major third = warmth and balance of opposites

Interval (Powerful Transformation)

Move: *Parting the Wild Horse's Mane*

- Long inhale 3 counts (preparation), swift exhale 1 count (release/push)
- Use this for expressive martial form (Fa Jin light version)
- Visualize harmonics flowing from body to space

Dynamic movement, focused on transformation and energy projection

Harmonic Stillness (5 Minutes)

Posture: Standing Like a Tree

- Return to 1:1 ratio breath
- Visualize a Lambdoma matrix grid gently pulsing in your energy field
- Feel all prior intervals integrated into a single harmonic body
- Optionally hum a low, steady tone — or use overtone throat singing for internal resonance

Optional Enhancements:

- Use tuned chimes or harmonic drones matching intervals (e.g., C-G for 3:2, CF for 4:3)
- Visualize colors linked to intervals (e.g., 1:1 = white, 3:2 = gold, 5:4 = violet)
- Try binaural beats or overtone recordings corresponding to harmonic intervals

A diagram of Lambdoma Harmonics Guided Tai-Chi Practice is lustrated (Figure 23) below for easy access and reference only.

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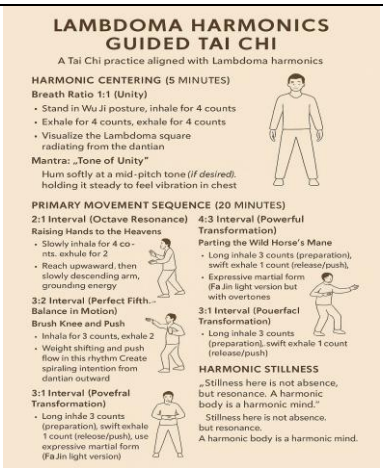

Figure 23. A Diagram of Lambdoma Harmonics Guided Tai-Chi Practice

Making Tai-Chi Motions As Circles And Spirals

Circles and Spirals in Tai-Chi Motions

It's well known that Tai-Chi is characterized by its flowing, circular, and spiral motions. These movement patterns are not merely aesthetic but deeply rooted in Taoist philosophy, biomechanics, and martial application. This section further explores the theoretical and practical significance of circles and spirals in Tai-Chi, illustrating how these patterns contribute to internal energy cultivation (qi), structural integrity, and combat effectiveness.

A closer inspection reveals that circles and spirals are fundamental to both its form and function. These geometrical motifs echo the Taoist worldview of natural harmony, cyclical processes, and dynamic balance. Here we examine the role of circular and spiral motion in Tai-Chi from three perspectives: philosophical foundations, biomechanical principles, and martial applications.

As we already know the origins of Tai-Chi lie in Taoist cosmology, particularly the concepts of *Yin-Yang* and the *Taiji* (Supreme Ultimate) symbol, which itself is circular (Figure 1.1). The perpetual interplay between yin and yang reflects a dynamic balance, represented by curving lines and rotational motion rather than linear opposition. In Tai-Chi practice, movements embody this philosophy through continuous, circular gestures that maintain fluidity and connection between opposing forces.

Spirals, in particular, are symbolic of growth, transformation, and the unfolding of potential. Taoist alchemical texts and traditional Chinese medicine emphasize spiral movement as a natural pattern in both the cosmos and the human body (e.g., DNA helices, energy meridians). Thus, the circular and spiral movements (Figure 24-25) in Tai-Chi align the practitioner's body and consciousness with universal rhythms.

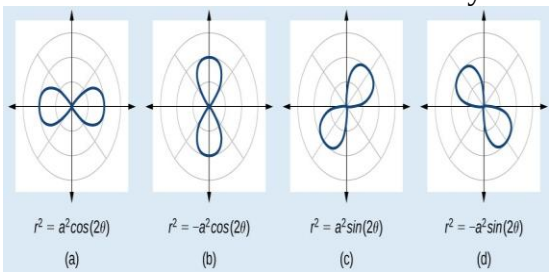

Figure 24. Lemniscate Motions of Tai-Chi Movements

From a physiological standpoint, circular and spiral motions optimize efficiency, minimize joint strain, and facilitate whole-body coordination. Tai-Chi emphasizes the integration of movement from the *Dantian* (energy center located in the lower abdomen), with motion propagating outward in spiral patterns through the torso and limbs. This spiraling is often described in traditional terminology as *chán sī gōng* (silk-reeling energy), a key concept in Chen-style Tai-Chi (Wang, 2010).

Spiral motion allows for the simultaneous expression of expansion and contraction, enabling the practitioner to store and release energy smoothly. Moreover,

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rotational motion provides greater mechanical advantage for redirecting external force, enhancing stability and power without relying on muscular tension. This principle supports Tai-Chi's maxim of "*using four ounces to deflect a thousand pounds.*"

In combat, the circular and spiral techniques of Tai-Chi enable redirection, absorption, and neutralization of an opponent's force. Circular stepping and pivoting create angles that destabilize opponents while preserving the practitioner's balance. Spiral techniques such as wrapping, coiling, and uncoiling facilitate joint locks, throws, and strikes that are subtle yet effective.

For example, when executing a push or a strike, the spiraling of the forearm and rotation of the waist allow for a power transmission that is rooted in the ground and unified through the body. This is often imperceptible but highly effective, exemplifying the internal nature of Tai-Chi power.

Additionally, circularity in form practice ensures continuity and flow, training the practitioner to remain adaptable and unbroken in the face of changing situations—a core martial and philosophical tenets.

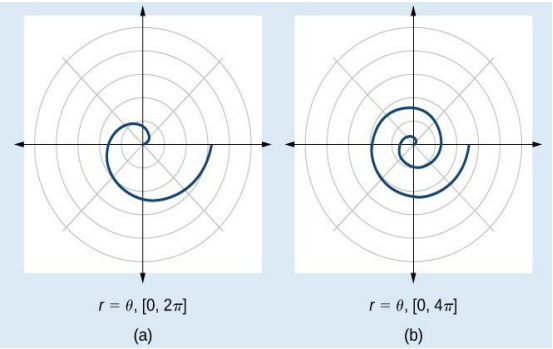

Figure 25. Circular and Spiral Motions of Tai-Chi Movements

The circular and spiral motions of Tai-Chi are more than stylistic flourishes; they are expressions of a deeply integrated system that encompasses philosophy, physiology, and martial efficacy. These patterns promote internal harmony, efficient biomechanics, and sophisticated combat tactics. Understanding and embodying these principles is essential for the development of Tai-Chi as both a martial art and a path of internal cultivation.

Circles and Spirals Guided Tai-Chi Teaching and Learning

Here's a Circles and Spirals Guided Tai Chi Motions sequence that emphasizes circular and spiral energy—concepts central to Tai-Chi principles like softness, flow, and internal strength. This sequence is great for warm-ups, meditation, or as part of a longer practice.

Circles and Spirals Guided Tai-Chi Flow (5–10 minutes)

Opening – Centering Breath

- **Motion**: Stand in Wuji stance (feet shoulder-width apart, knees slightly bent, arms at sides).
- **Breathing**: Inhale through the nose as you lift both arms in a wide circle up to chest height, palms facing down. Exhale through the mouth as you lower them.
- **Focus**: Feel the breath creating an internal circular rhythm.

Spiral the Wrists

- **Motion**: Raise hands to shoulder height, palms down. Slowly rotate the wrists in inward spirals, then reverse to outward spirals.

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- **Visualization**: Imagine small whirlpools at each wrist, generating energy.
- **Breathing**: Inhale as the spiral expands, exhale as it contracts.

Silk Reeling Hands (纏絲功, chán sī gōng)

- **Motion**: One hand circles outward and upward, while the other hand spirals inward and downward. Alternate hands in continuous motion.
- **Focus**: The spiral begins from the Dantian (lower abdomen), through the shoulder, to the fingertips.
- **Breathing**: Inhale when the arm rises and expands, exhale when it lowers and coils.

Cloud Hands – Horizontal Spirals

- **Motion**: Shift weight side to side as one hand "clouds" across the body in a horizontal arc, while the other hand mirrors it lower down.
- **Footwork**: Step side to side gently.
- **Focus**: Arms trace sideways spirals, with waist leading the motion.
- **Breathing**: Natural, synced with movement.

Spiral Spine Twist

- **Motion**: Gently rotate torso left and right, arms loose and following like pendulums.
- **Spiral Element**: Imagine the spine as a spiral column unwinding.
- **Breathing**: Inhale as you return to center, exhale on each twist.

Arm Spirals (Dragon Swims Through Clouds)

- **Motion**: Raise one arm overhead in a spiraling path, tracing a figure-eight in the air. Follow with the other arm.
- **Focus**: Move from the shoulder and spine, not just the arms.
- **Breathing**: Smooth and continuous.

Closing – Gathering Energy

- **Motion**: Circle arms out to the sides and then scoop forward and down toward the Dantian (lower belly), as if gathering energy.
- **Breathing**: Inhale as arms rise and circle, exhale as you gather energy inward.

Tips for Practice

- Move slowly and fluidly, with no sharp edges.
- Feel each joint spiral is like gears in a smooth machine.
- Let the waist lead the limbs.
- Keep your eyes soft and breathe steadily.

Practicing Tai-Chi as Living Mathematics

Mathematics-Guided Tai-Chi Practice

As we have seen the interrelations between Tai-Chi motions and mathematical structures, we propose a conceptual mathematics-guided integrative framework that unifies Tai Chi motions with the Lo

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Shu Magic Square, Fibonacci numbers, the Golden Ratio (φ), Lambdoma harmonics, and circular and spiral motion. This framework is both symbolic and practical, designed to enrich the understanding and its teaching and learning of Tai-Chi through mathematical and harmonic principles.

1. **Lo Shu Pathways:** Walking patterns on a 3x3 grid improve balance and spatial harmony.
2. **Fibonacci Flow:** Movement intervals and breath work mirror natural rhythms.
3. **Golden Postures:** Structural alignment based on φ for biomechanical efficiency.
4. **Lambdoma Music:** Matching postures to tones deepens sensory engagement.
5. **Spiral Visualization**: Spiral drills enhance kinetic flow and structural fluidity.

Mathematics-Guided Integrative Framework for Tai-Chi Motion will be presented in Table 8.1 and Table 8.2.

Foundational Structure: The Lo Shu Magic Square

The Lo Shu Square is a 3x3 magic square (Figure 3.2) from ancient China, foundational in Feng Shui and Taoist cosmology.

- All rows, columns, and diagonals sum to 15, reflecting symmetry and balance—core Tai Chi principles.
- The center (5) corresponds to the Dantian (energy center in Tai Chi).
- Movements are mapped to the 9 positions as stepping directions or body alignments, with each number also assigned to an elemental quality (Fire, Water, Earth, etc.).

Motion Mapping:

- Each position becomes a spatial reference for body alignment or step in the form (e.g., WUJI stance at 5, step to 8 or 2 for a diagonal expansion).
- Flow through the square in Fibonacci spiral progression (see below) to trace natural motion arcs.

Fibonacci Numbers and the Golden Ratio (φ ≈ 1.618)

Fibonacci & Tai-Chi Timing:

- Use Fibonacci sequence (1, 1, 2, 3, 5, 8, 13…) to time breaths and motions (e.g., inhale for 3 counts, exhale for 5).
- The growth pattern models natural energy expansion, from center to periphery—mirroring Tai Chi's internal-to-external energy flow.

Golden Ratio in Motion:

- Body spirals (e.g., in *cloud hands*) can be choreographed to approximate Golden Spiral arcs.
- Transition paths between stances follow φ-curves (logarithmic spirals), optimizing biomechanical efficiency and aesthetic harmony.

Visualization:

- Draw a golden spiral over the Lo Shu square. Let movement flow from center

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(5) out to 1 → 2 → 3... in spiral Fibonacci expansion.

Lambdoma Harmonics: Sound and Movement Resonance

Lambdoma Matrix represents integer harmonic ratios, used by Pythagoreans for sound healing. Each cell is a frequency ratio (e.g., 1:2 = octave, 2:3 = fifth).

Harmonic-Motion Integration:

- Assign movement phases or gestures to harmonic intervals.
    - E.g., 1:2 (octave) = rising motion (Yang), 2:3 (fifth) = spiral turn.
- Breath or vocal tones can be intoned at intervals corresponding to movement dynamics (raise hands = perfect fifth hum).

Integration Strategy:

- Map harmonic intervals to Lo Shu positions:
    - Center (5) = 1:1 (unison)
    - Corners = 2:3, 3:4 (fifth, fourth)
    - Edges = 3:5, 5:8, etc. (Fibonacci-derived harmonics)

Use a tonal drone tuned to these intervals to enhance meditative awareness during practice.

Circular and Spiral Motions: Geometry of Flow

Tai-Chi is inherently circular. Combining it with spiral geometry rooted in φ and Lambdoma adds depth.

Circular Motion:

- Each form has a central axis (torso/Dantian) about which limbs rotate.
- Use unit circles centered on Lo Shu points to choreograph arcs.

Spiral Motion:

- Spirals reflect energy projection, from core (Dantian) to limbs.
- Fibonacci spirals define spatial travel paths and limb trajectories (e.g., spiraling arms in "Parting Wild Horse's Mane").

Framework Summary: Integrative Map

Table 9. Integrative Map

Component	Mapped To	Tai Chi Relevance
Lo Shu Magic Square	Spatial movement, step direction	Structure, grounding, Yin-Yang dynamics
Fibonacci Sequence	Breath cycles, timing	Natural rhythm, organic flow
Golden Ratio (φ)	Path geometry, spirals	Aesthetic, energetic efficiency
Lambdoma Harmonics	Sound, breath, internal rhythm	Resonance, internal alignment
Circular/Spiral Motion	Form paths, Dantian expression	Power projection, balance, centeredness

Practice Sequence Example

Form Module: "Golden Flow Spiral"

1. Begin in WUJI (center 5 of Lo Shu)

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2. Step outward to 2 (Fibonacci step 1)
3. Spiral hand movement tracing φ arc to 7 (step 2)
4. Pause and hum a perfect fifth (2:3) interval tone
5. Return to center with inhale over 5 counts
6. Expand into a larger arc: 8 → 1 → 6 → 3, tracing a Golden Spiral across the Lo Shu field
7. Conclude with a closing circle motion, tracing the full perimeter of the square with fingertips

Here's the "Golden Flow Spiral" plotted (Figure 26) inside the 3×3 Lo Shu magic square, showing your described movement from Wuji (center) outward and spiraling through the Fibonacci-inspired steps

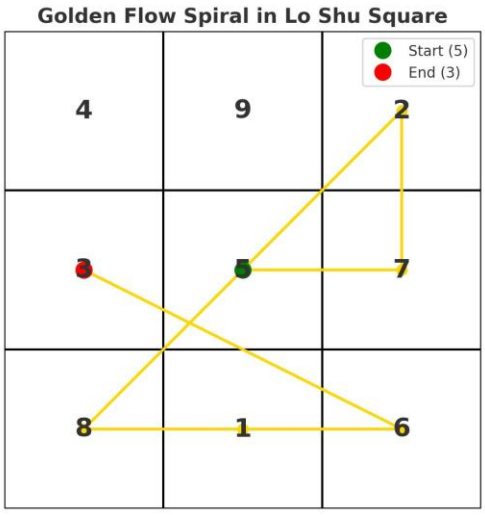

Figure 26. Golden Flow Sprial

This integrative model links body, breath, sound, number, and geometry into a harmonized system of practice. It transforms Tai Chi into a living embodiment of mathematical harmony, ancient wisdom, and energetic precision.

Table 10 Summary of Mathematical Concepts and Tai-Chi Applications

Concept	Tai-Chi Application	Benefit
Lo Shu	Movement sequencing	Balance, spatial awareness
Fibonacci	Breathing, repetition	Rhythmic flow, focus
Golden Ratio	Body alignment	Aesthetics, efficiency
Lambdoma	Music-movement syncing	Coordination, entrainment
Spirals	Silk reeling	Power transmission, fluidity

Closing

At the opening, we see the correspondence between mathematical numbers 0 2, 3, 4, 5, 6, 7, 8, 9, 10 and Tai-Chi motions. Throughout our Tai-Chi motions, we have demonstrated various geometric shapes associated with Tai-Chi movements. Fundamental geometric shapes in Tai-Chi motions reflect the underlying philosophy of natural harmony, energy flow, and body structure. These shapes are not just abstract, they are embodied through form, movement, and intention. As we are preparing for closing, we take an overview of eight geometric shapes foundational to Tai-Chi practice:

Circle (圓形) – Continuous Flow and Unity

- **Symbolism**: Completeness, infinity, harmony.

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- **In Motion**: All Tai-Chi techniques aim for **circularity**—in hand paths, stepping, turning, and internal energy flow (Qi).
- **Examples**: Rotating the waist (Dantian rotation), circular arm movements, silk reeling (缠丝功).
- **Philosophy**: The circle represents the Dao and eternal motion without beginning or end.

Spiral (螺旋形) – Internal Energy Dynamics

- **Symbolism**: Transformation, rootedness, expansion.
- **In Motion**: Spiral movements generate torque and internal power (jin). It's seen in coiling and uncoiling, twisting, and connecting the whole body.
- **Examples**: Silk reeling, punching, or issuing force (fajin) from the core.
- **Energy Path**: Qi spirals outward from Dantian to limbs.

Line (直线) – Intentional Direction

- **Symbolism**: Intent (意), focus, directness.
- **In Motion**: Linear paths guide direction, strikes, and projections.
- **Examples**: Stepping forward/backward (jin/tui), pushing hands application, directional pointing with the hands or eyes.
- **Note**: Even linear motion contains micro-circular and spiral forces inside.

Square (正方形) – Structure and Balance

- **Symbolism**: Earth, stability, four directions.
- **In Motion**: Used in foundational stances and stepping—anchoring the body and defining boundaries of movement.
- **Examples**: The Four Corners (四隅), Five Steps (五步) which form a cross or square orientation.
- **Geometry**: Represents control of space—front/back, left/right.

Triangle (三角形) – Stability and Connection

- **Symbolism**: San Cai (Heaven–Earth–Human), grounding and upward force.
- **In Motion**: The stance often forms triangles—between legs and ground, between torso and arms.
- **Examples**: Bow stance (弓步) and weight shifting rely on triangular bases of support.
- **Structure**: Energy rises through one point while grounding through the base.

Sphere (球体) – Internal Wholeness

- **Symbolism**: Protective field, unity of body and mind.
- **In Motion**: The practitioner imagines moving inside or manipulating a **sphere of energy**—this develops spatial awareness and smooth transitions.
- **Examples**: Holding the ball (抱球), Tai-Chi ball rotation drills.

Infinity Loop (∞, 太极图轨迹) – Continuous Flow Between Yin and Yang

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- **Symbolism**: Unbroken motion, interplay of Yin and Yang.
- **In Motion**: Hands or torso trace figure-eight paths.
- **Examples**: Cloud hands (云手), walking spirals, Tai-Chi symbol unfolding in motion.

Cross (十字形) – Center and Axis

- **Symbolism**: Central equilibrium, dual axes (vertical and horizontal).
- **In Motion**: Defines alignment and transition between postures.
- **Examples**: Central Dantian alignment crossing with shoulder-hip axis; defining cardinal stepping points.

For quick and easy access, we summarize Tai-Chi motion basic geometry in the following table (Table 11) below.

Table 11 Basic Geometric Shapes of Tai-Chi Motions

Shape	Figure	Function in Tai-Chi	Example Motion
Circle		Smoothness, unity, cyclic flow	Arm rotations, waist turning
Spiral		Power generation, Qi flow	Silk reeling, issuing force
Line		Direction, intention	Stepping, pushing
Square		Balance, grounding, spatial control	Stances, 5-step footwork
Triangle		Stability, energy transfer	Bow stance, rooted transitions
Sphere		3D awareness, wholeness	Holding the ball, torso motion
Infinity		Yin-Yang dynamics, wave flow	Cloud hands, turning sequences
Cross		Centerline awareness, axis orientation	Postural alignment

In Tai-Chi, in addition to geometric shape, numbers are playing a vital role, they are symbolic of principles of nature, balance, motion, and transformation. The foundational digits 0–9 carry philosophical, geometric, and energetic meanings that parallel the movements and theory of Tai-Chi. Below is a table (Table 12) listing mathematical base numbers in Tai-Chi motions.

Table 12. Mathematical Base Numbers in Tai-Chi Motions

Number	Tai-Chi Meaning	Concept
0	Wuji	Stillness, source, potential
1	Tai Chi	Unity, origin
2	Yin-Yang	Duality, balance

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3	San Cai	Heaven-Earth-Human harmony
4	Four Directions	Grounding, orientation
5	Five Steps	Motion principles
6	Six Harmonies	Internal & external unity
7	Seven Stars	Body articulation and cosmic order
8	Eight Gates	Energy techniques
9	Completion	Dynamic culmination, spiritual rise, highest Yang
10	Return to Unity (1+0)	Completion and returning to origin. While not among the base digits, 10 = 1 + 0, signifying a full cycle.

When Tai-Chi is in motion, it moves continuously, smoothly, and harmonically as a moving sphere (Figure 27).

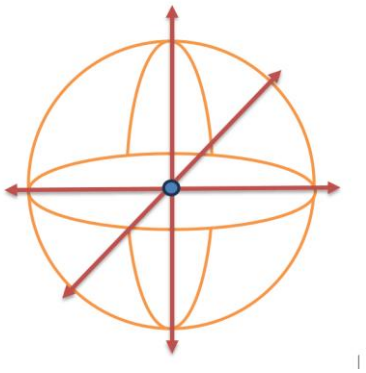

Figure 27. Tai-Chi Sphere in Motion

Three principal Tai-Chi circles (horizontal-xz plane, vertical-yz plane, lateral-xy plane) can be projected into a 3-D space in the following coordinate system (Figure 28).

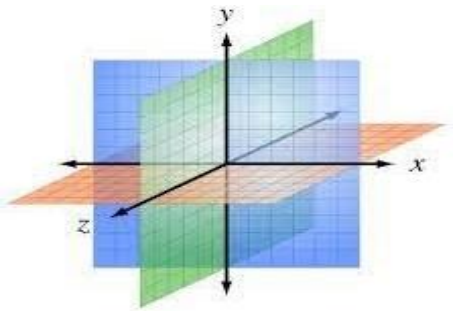

Figure 28. Mathematics Coordinate System (3D)

This coordinate system allows to visualize Tai-Chi motion as a symbolic interconnected multi-integral of body motion (Ti-体), Breath Energy (Qi-气), and Mind Intention (Yi-意) differentiated over time t (时间) from 0 to ∞:

$$\textit{Tai-Chi Motion} = \iiint \textit{[(Body Motion-体) + (Breath Energy-气) + (Mind Intention-意)]}\partial \textit{Time}$$

This conceptual mathematical integral opens a door for us to navigate Tai-Chi space through the lenses of mathematics. Mathematics and Tai-Chi reveal profound synergies when viewed through the shared lenses of geometry, rhythm, and proportion. This initial work demonstrated

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that mathematical structures—ranging from the Lo Shu Magic Square and Fibonacci sequences to the Golden Ratio, Lambdoma harmonics, and spiral dynamics—can provide meaningful frameworks for enhancing Tai-Chi practice. These connections not only deepen the philosophical and structural understanding of movement but also offer practical applications for balance, rhythm, alignment, and energetic coherence.

The proposed mathematics-guided framework provides a novel approach for both practitioners and educators, enabling a more integrative and reflective experience. By grounding Tai-Chi in mathematically inspired principles, we open new pathways for meditative, rehabilitative, and educational uses.

Future work should focus on developing digital tools—such as mobile apps and motion capture systems—to help visualize, analyze, and guide math-integrated Tai-Chi forms. Empirical studies are also needed to evaluate the cognitive, emotional, and physical benefits of this approach in diverse populations and settings. In addition, further exploration into emerging mathematical domains—such as fractal geometry, non-Euclidean space, and quantum harmonics—may offer deeper insights into advanced Tai-Chi dynamics and their potential applications across science, art, and wellness.

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Conflict of Interest

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Appendices

In the following Appendices, we first list 13 fundamental Tai-Chi movements (Appendix 1) and the popular 24-form of Tai-Chi routine (Appendix 2) for ease access and practice reference. To prob deeper into the inner/outer three-in-one Tai-Chi motions, we illustrate dynamic geomatic shapes of fundamental Tai-Chi movements in Appendices 3-9. It's hoped that these geometric shapes of Tai-Chi movements will open a new Tai-Chi platform for further scientific and intuitive investigations of Tai-Chi motions as Moving Geometree.

Appendix 1

8 Fundamental Hand Movements and 5 Fundamental Foot Movements

No	Movement (8 hands and 5 feet movements)	Basic Movement Description
1	Ward-off-Peng	A Kind of "bouncing" energy, fundamental way of delivering energy and embodied in each of the other 8 arm movements
2	Roll back-Lu	Inward receiving and collecting energy
3	Press-Ji	Pressing and receiving energy, an offensive force delivered by following the opponent's energy
4	Push-An	Downward pushing energy, pushing power comes from the legs pushing into the earth
5	Pull Down-Cai	Grabbing energy, a force delivered by a quick grab and pull backward and down
6	Split-Lie	Striking energy that splits apart an opponent
7	Elbow-Zhou	Elbow-striking energy
8	Shoulder- Jian	A full body striking energy, the peng energy is mobilized throughout the entire body, and then the entire body is used as one unit and the force is delivered with the shoulder or back.
1	Advancing Steps-Jin	Advancing steps, Stances, and Looking front (Jin Bu)
2	Retreating Steps-Tui	Retreating steps, Stances, and Looking back (Tui Bu)
3	Stepping to left side-Gu	Left Side Moving Steps, Stances, after Gazing to the Right (You Pan) or faking to the right. Movement to the left and looking to the left
4	Stepping to right side-Pan	Right Side Moving Steps, Stances, after Looking to the Left (Zou Gu) or faking left. Movement to the right
5	Settling at the CenterDing	Settling at the Center, Rooting Stances, and Holding Still – Zhong Ding. Centering, holding to one's center, maintaining equilibrium, settling,

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		moving downward, and staying balanced at one's center

Appendix 2

24-Form Tai-Chi

(Each posture is a sequence of combinations of 13 basic movements)

1	Commencing (Qǐshì, 起势), Preparation, Beginning
2	Part the Wild Horse's Mane (Zuǒyòu Yěmǎ Fēnzōng, 左右野马分鬃), LEFT and RIGHT
3	White Crane Spreads Its Wings (Báihè Liàngchì, 白鹤亮翅), Stork/Crane Reveals Its Wings
4	Brush Knee and Step Forward (Zuǒyòu Lōuxī Àobù, 左右搂膝拗步), Brush Knee and Twist Step, LEFT and RIGHT
5	Playing the Lute (Shǒuhūi Pípā, 手挥琵琶), Strum the Lute, Play Guitar
6	Reverse Reeling Forearm (Zuǒyòu Dào juǎn gōng, 左右倒卷肱), Step Back and Repulse Monkey (Dǎo niǎn hóu 倒撵猴), LEFT and RIGHT
7	Left Grasp Sparrow's Tail (Zuǒ Lǎn Què Wěi, 左揽雀尾), Grasp the Bird's Tail 1. Ward Off (Bīng, 掤) 2. Rollback (Lǚ, 捋) 3. Press (Jǐ, 挤) 4. Push (Àn, 按)
8	Right Grasp Sparrow's Tail (Yòu Lǎn què wěi, 右揽雀尾)
9	Single Whip (Dān biān, 单鞭)
10	Wave Hands Like Clouds (Yúnshǒu, 云手), Cloud Hands, Cloud Built Hands, Wave Hands in Clouds
11	Single Whip (Dān biān, 单鞭)
12	High Pat on Horse (Gāo tàn mǎ, 高探马), Step Up to Examine Horse
13	Right Heel Kick (Yòu dēng jiǎo, 右蹬脚), Separate Right Foot, Kick with Right Foot
14	Strike to Ears with Both Fists (Shuāng fēng guàn ěr, 双峰贯耳)
15	Turn Body and Left Heel Kick (Zhuǎnshēn zuǒ dēngjiǎo, 转身左蹬脚)
16	Left Lower Body and Stand on One Leg (Zuǒ Xià shì dúlì, 左下势独立) 1. Single Whip Squatting Down, Snake Creeps Down, 2. Golden Rooster Stands on One Leg, Golden Bird Standing Alone
17	Right Lower Body and Stand on One Leg (Yòu Xià shì dúlì, 右下势独立)
18	Shuttle Back and Forth (Yòuzuǒ yùnǔ chuānsuō, 右左玉女穿梭), Fair Lady Works with Shuttles, (Walking Wood), Four Corners, RIGHT and LEFT
19	Needle at Sea Bottom (Hǎidǐ zhēn, 海底针)
20	Fan Through Back (Shǎn tōng bì, 闪通臂), Fan Penetrates Back
21	Turn Body, Deflect, Parry, and Punch (Zhuǎnshēn Bānlánchuí, 转身搬兰捶)
22	Apparent Close (Rúfēng shìbì, 如封似闭), Withdraw and Push, as if Closing a Door
23	Cross Hands (Shízìshǒu, 十字手)
24	Closing (Shōushì, 收势)

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Appendix 3

Moving Geometree of Tai-Chi Motion

15-Points Diagram of Moving Geometree

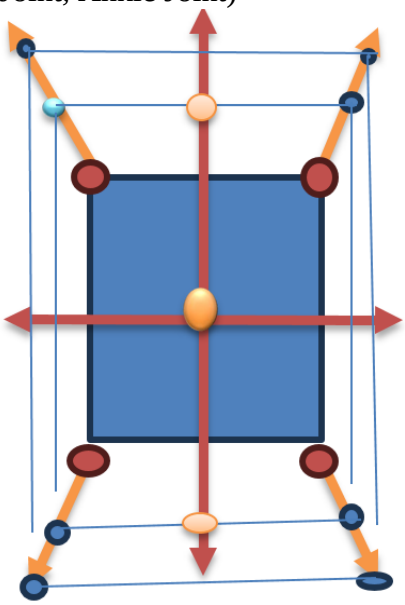
Inner and Outer Three-in-One Tai-Chi Motion Geometree 6 Tai-Chi Harmonies (内三合， 外三合)

Central 5 Points (Center, 2 Shoulder Joints, 2 Hip Points)

Inner Three Central Points (意-Yi, 气-Qi, 体--Ti)

Left 4 Points (Wrist joint, Elbow Joint, Knee Joint, Ankle Joint)

Right 4 Points (Wrist joint, Elbow Joint, Knee Joint, Ankle Joint)



Appendix 4

Still Geometree of Opening of Tai-Chi Motion

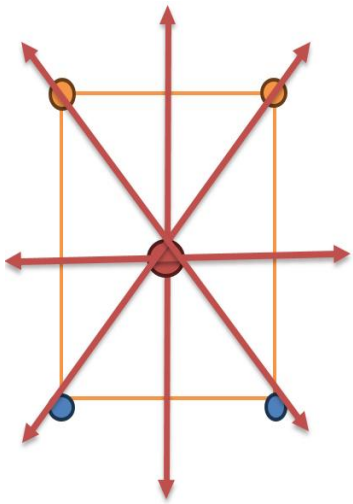
（太极开始几何树形）

5-Points Diagram Standing Geometree

1 Central Point (Center)

2 Left Points (Shoulder Joint, Hip Joint)

2 Right Points (Shoulder Joint, Hip Joint)



Appendix 5

Tai-Chi Motion Moves On a Light Cone

（太极 运动光圆椎形）

Energy Center (丹田)

1 Central Point (Center)

2 Left Points (Shoulder Joint, Hip Joint)

2 Right Points (Shoulder Joint, Hip Joint)

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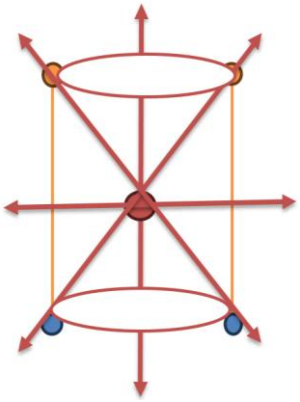


Appendix 6

Standing Geometree-Wuji Position Of Tai-Chi Motion

(**无极椿功几何**树形)

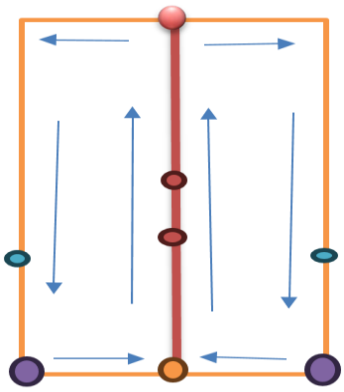
8-PointsDiagram of Standing Geometree

4 Central Points (**大椎点**，**命**门点，尾闾点，涌泉中点)

2 Left Points (风市点，**涌泉点**)

2 Right Points (风市点，**涌泉点**)

Left Side Cycle in Counterclockwise Right Side Cycle in Clockwise



Standing Geometree-Circle Position of Tai-Chi Motion

Appendix 7

3-Circles Sphere Diagram of Standing Geometree

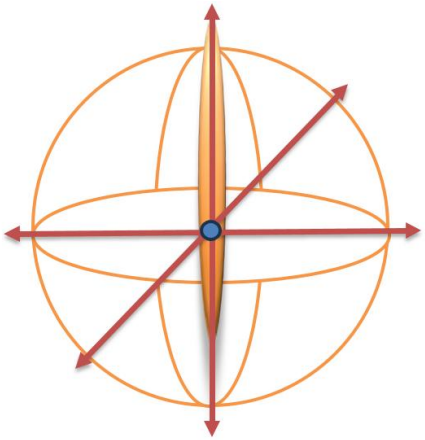
(鸿园椿几何树形)

外圆(All Directions within a Sphere) **横**圆

(Horizontally Left to Right0

竖圆 （Vertically Top to Bottom）

$|X|^2+|Y|^2+|Z|^2=R^2$



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Appendix 8

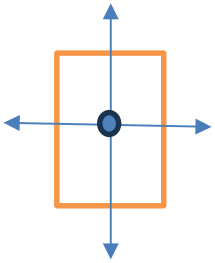
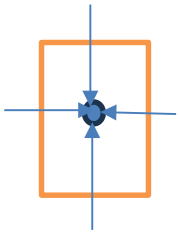
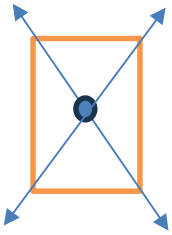
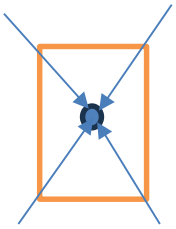
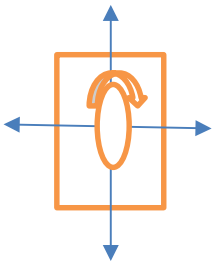
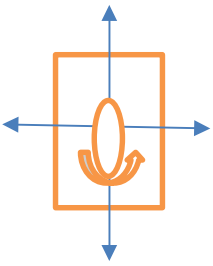
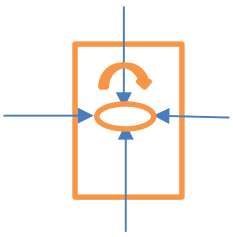
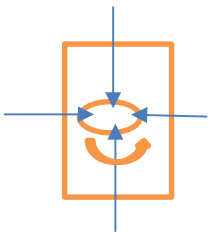
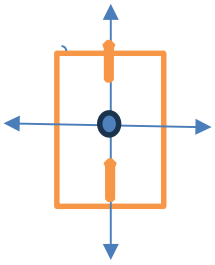
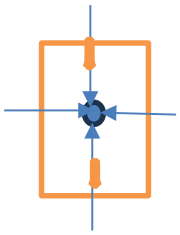
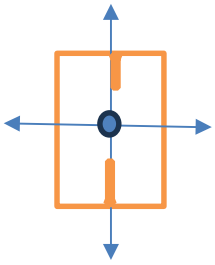
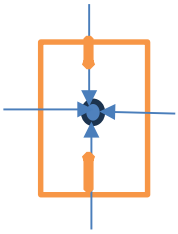
Tai-Chi Golden Rectangle Motion Potentials

Tai-Chi Breathing States: Inhale, Exhale, Hold

Golden Rectangles: Vertical (V), Horizontal (H), 4-Faces; Diagonal (D), 4-Corners

Rotation Directions: Clockwise (C), Counterclockwise (CC) 8 Movements: 4 Faces: M9 M1 M3 M7; 4 Corners: M2 M8 M4 M6

Movement Directions: Concave Up (CU), Concave Down (CD)

V/H Inhale 	**V/H Exhale** 	**D Inhale** 	**D Exhale** 
V/C Inhale 	**V/CC Inhale** 	**H/C Exhale** 	**H/CC Exhale** 
CU Inhale (M_9) 	**CD Exhale (M_1)** 	**CUD Inhale (M_3)** 	**CDU Exhale (M_7)** 

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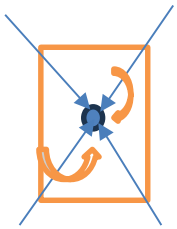
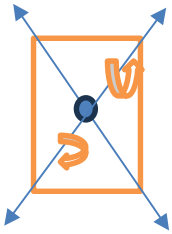
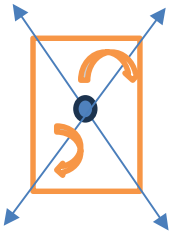
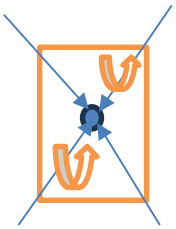
D Inhale (M_2)	**D Exhale (M_8)**	**D Inhale (M_4)**	**D Exhale (M_6)**
			

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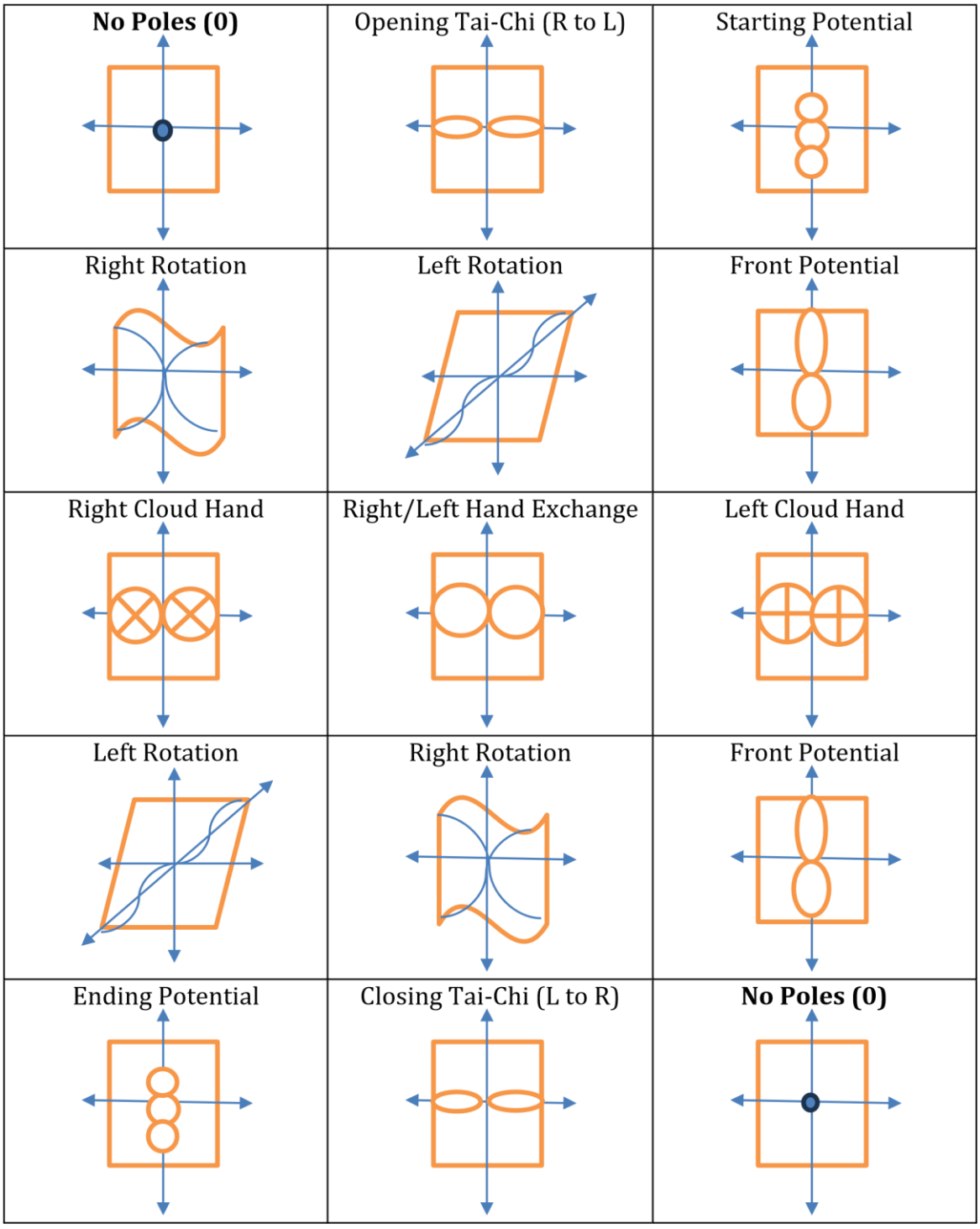
Appendix 9

Geometric Shapes of 13 Tai-Chi Motion Potentials

Tai-Chi Motion Potential Consists of 8 Movements: M1 M9 M3 M7} & {M2 M4 M6 M8}



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